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AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT, } Editors.
E. A. AVERILL, }

JUNE, 1908

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ture," presented by G. M. Basford before the 1905 meeting of the Master Mechanics' Association. Mr. Basford directed attention to the importance of this question and to the need of improved methods in handling apprentices and explained the underlying general principles upon which a successful apprentice system should be based.

At the 1907 convention C. W. Cross and W. B. Russell presented a paper describing in detail the apprenticeship system on the New York Central Lines, which is based on the general principles advocated by Mr. Basford. This paper, like Mr. Basford's, was most enthusiastically received—indeed, was considered by many to be the most important subject considered at the convention.

Since the last convention several of the railroads have taken active steps to establish and improve their apprentice systems. The number of apprentices at the nine shops on the New York Central Lines, which have apprentice schools, has increased considerably and one new school has been established on the Michigan Central at St. Thomas. The Santa Fe, with F. W. Thomas as superintendent of apprentices, has established ten schools, taking care of between 300 and 400 apprentices. Several other roads have taken the matter up, among which may be mentioned the Union Pacific, Southern Railway and the Delaware & Hudson; railroads which previously had apprentice systems in effect have made important improvements and substantial progress.

The committee on apprenticeship for the coming convention, as part of its report, will have a practical exhibit of apprentice training and methods in booth 67 on the pier. This exhibit is being very carefully prepared and will show the development of the apprentice system on several of the roads. The committee is to be congratulated on taking this radical and unique step. It is sure to be a success, especially if some of the members of the committee will be at the exhibit, at stated periods each day, to explain the details and answer questions.

OPERATION OF MALLET LOCOMOTIVES.

A recent test of one of the Mallet articulated compound locomotives on the Erie Railroad, the more general results of which are given on page 212 of this issue, revealed a number of very interesting features peculiar to this type of locomotive. These are fully described in the article and it is the intention here to mention a few of the points noticed in several days' observation of the locomotives in their regular service.

As might be expected, the most impressive feature is the enormous amount of power which is under the control of one engineer and is furnished by one fireman. A closer examination shows that this power is fully under the control of the engineer and that these engines can be handled as easily and as accurately as can much smaller machines. This feature is particularly noticeable in spotting the engines on the turntable, where they are often moved less than 1 in. and can be balanced with the greatest accuracy. When the locomotives were first put into service it was believed that so large a machine was beyond the physical ability of one fireman to develop the power required, but after several months' trial the second man was taken off and at present one fireman is doing the work. Such an arrangement would not be possible if the locomotives were to operate at full power for any great length of time, but under the conditions in which they are now being worked, requiring them to develop approximately three-quarters of their theoretical effort for a distance of about seven miles and a time of about one hour, one man is capable of handling them without any great difficulty. He is necessarily furnished with a good grade of coal, well broken.

The locomotives, at the time of these observations, had been in regular service about six months and a careful examination failed to disclose appreciable flange wear on any of the driving wheels. The tires were somewhat worn on the tread, but not more than would be the case with any heavy freight locomotive. The flexible joints in the receiver pipe showed no leakage and operated with the greatest ease. In fact, these monster locomotives are handled in the yards, through switches and cross-overs, with as much confidence as a six-wheel switch engine. In running through the yards at speeds as high as 15 to 20 miles per hour they take cross-overs with great smoothness and do not seem to have any bad effect on the track. The same feature is noticed when working at full power on very sharp curves, in that there is no binding or straining at any point. Taking everything into consideration, the experience so far would indicate that the articulated feature is a complete success.

In the matter of running repairs, there is, of course, much more to be done on one of these engines than there would be on a simple machine, and no doubt their expense in this regard is comparatively high. But when it is considered that they are doing the work which formerly required the service of three very large consolidation engines it will doubtless be found that the cost of running repairs for this pushing service is reduced by the introduction of these engines. It would naturally be expected that engines of this type would have an expense for running repairs approaching twice that of a heavy simple engine of the consolidation type. Observation in the engine house would lead one to think that it would not exceed this.

The engine crews in general express themselves to be perfectly satisfied with this type of power. The engineers find that the power reversing gear relieves them of much hard labor and are pleased with its operation. The manner in which the locomotives automatically take care of themselves when slipping, a feature which is mentioned in the article on page 216 also relieves the engineers to a considerable extent.

There are, of course, some minor points wherein the crews and management can see an opportunity for improvement, but taken altogether the locomotives can be said to be an entire success.

UNIVERSAL STANDARD FREIGHT CARS.

The communications on this subject, in another part of this issue, indicate that from a standpoint of economy and efficiency it would be advisable to secure a much more extensive standardization of freight car details than exists at present. Undoubtedly important advantages would result from the complete standardization of freight cars. This does not necessarily mean that there should be but one class, or one capacity, for each type of car. For instance, it might be advisable to have three or four or more different classes of box cars, differing in size and capacity, to meet the needs of the various districts in which they are to be used most extensively. However, the greater number of the details of the different types of the same capacity could be standardized and undoubtedly a large number of common standards could be adopted for all classes and capacities of cars.

It is true that several systems have each standardized their equipment to some extent and that the standard cars of such roads differ very greatly from each other in detail; this, of course, would make it more difficult to adopt common standard cars on such roads. It hardly seems necessary, especially with the cars interchanged as generally as they are at present, that four or more roads covering the same territory and operating under similar conditions should each require a radically different design for each type of freight car. Each road is, of course, sure that it has the best car, but can they prove it on a dollar and cents basis? Under present conditions of interchange and accounting it is practically impossible to determine the actual cost of maintaining any one car or class of cars. The cars of each of the several roads may be equally good, although differing greatly in design. On the other hand, they could probably all be improved in certain details by combining the experience of the officers of all the roads. Common standard cars designed in this way would probably be more satisfactory than the cars of any one of the roads, but, even admitting that they were not better, if they were adopted and maintained by the roads interested, a marked advance in efficiency and economy would result.

* * * * * * *

It would be interesting to know what the fads or hobbies of individuals are costing the railroads of this country each year. Doubtless you will say that there can be no progress if the in-

dividual does not work out the problems confronting him in his own way. This may be true to a certain extent, but experience has demonstrated that the combined efforts of several experts is much more valuable than the opinion of the individual. How many worthless devices have been tried and found wanting on your road within the past few years? Is there any need of each device being tested by a number of different roads? Would it not be much better and more economical to have some arrangement whereby the tests could be confined within reasonable limits and without putting the railroads to such a heavy expense to develop different devices, as is allowable under present conditions?

* * * * * * *

Apparently the only way in which complete standardization can be brought about is by following the suggestion made by Mr. Kruttschnitt, *i. e.*, that the initiative in this matter should be taken by the executive heads of some ten or twelve large systems and that these gentlemen issue positive instructions to their car builders to agree on standards and then adopt them. Because of the importance and the great extent of this work it would probably be necessary to place it in the hands of a commission made up of representatives from the different systems. A very careful study would first have to be made by properly qualified experts to determine just what types, capacities and sizes of cars should be adopted as standard in order to best meet the traffic and operating conditions on the different roads. When these have been decided upon the details could be worked out by mechanical experts.

There has been such a rapid advance in the art of car designing during recent years that there should be little difficulty in devising strong and serviceable cars of light and durable construction. The greatest difficulty would be in connection with the steel cars, but different types of these cars have been in service for some considerable time, and with the experience that has thus far been gained it would now seem possible for an intelligent committee to select designs which would give splendid results. The committee might possibly fail in selecting the best possible combination of details, but the advantages of having standard cars would be so great as to many times offset this. There are too many "fads" in steel car design and common sense and good engineering would indicate that some of the so-called good "talking points" of different makes of cars are really weaknesses when it comes to handling the car in the repair yard.

Adopting common standard cars does not mean that progress in design must come to a standstill. As conditions change the designs which might be adopted at the present time would have to be modified, but the modifications could be made so that the larger proportion of the common standards could be retained, even though it was necessary to change the capacity and sizes of the cars. The matter of maintaining the common standards and keeping them up to date should be in the hands of a standing committee, or commission, to whom all new designs and devices should be referred. This committee should be given sufficient power so that such devices as seemed to possess merit could be thoroughly tested out.

* * * * * * *

In connection with the problem of deciding upon common standards, and changing common standards, the following extracts, from a paper on "The Purchasing Department and Common Standards," presented before the New York Railroad Club by W. V. S. Thome, director of purchases of the Harriman Lines, are of interest:

"In numerous conferences, which are held periodically, the chief officials of each department concerned, of the various associated companies, have recommended exactly what many of these standards should be. Decisions have been made after considering the advantages from a mechanical and practical, as well as from a commercial point of view, and after opportunity has been given for argument or suggestions from many experienced and technical men, who have used or manufactured the devices or material in question. Later most of these recommended standards have been favorably passed on by a majority of the general managers of the companies concerned, and when formally approved by the director of maintenance and operation of the associated systems have thus been adopted as common standards for all the associated lines.

"When formally adopted, any article remains a common standard until it has been formally canceled or superseded by another device, which the officials concerned have voted to be preferable, either on account of greater efficiency, safety, economy, simplicity or other good and sufficient reason. This method has been found to work most satisfactorily in practice and without too much red tape to be objectionable."

* * * * * * *

If it was decided to adopt such standards it would be a few years before all of them could be worked out and the improved results due to standardization would probably not be apparent for a number of years, but when they did come they would undoubtedly be very great. Repairs would be facilitated and cars would not be held up on foreign lines awaiting the receipt of proper repair material; very much smaller stocks of repair parts could be carried; car builders could afford to build the cars much more cheaply; purchasing agents, equipped with complete specifications, could buy the repair material to better advantage and get better deliveries; standard material could be manufactured more cheaply in the railroad shops.

BOOK NOTE.

Betterment Briefs. By Henry W. Jacobs, Assistant Superintendent Motive Power, Atchison, Topeka & Santa Fe Railway, Topeka, Kansas. Edition de luxe. 6 x 9 in., 240 pages, 136 illustrations.

About four years ago the Santa Fe, under the direction of J. W. Kendrick, vice-president in charge of maintenance and operation, adopted a general plan of shop betterment. The methods followed were radically different from general railroad shop practice, but were based upon good, sound principles which have been advocated, in other lines of business, by the foremost betterment engineers.

The results have been very gratifying, not only to the workmen and those directly in charge of the shops, but to the *directors* and *stockholders* of the company. Its effects have, however, been much more far-reaching than this—the publicity which has been given to the work has done much to stimulate the wave of railroad shop improvement which has passed over the country during recent years. Many motive power officials, who are apparently not in sympathy with the work on the Santa Fe, will have to admit to themselves, upon careful analysis, that a study of the methods in use there, has stimulated them and helped them to better results.

From time to time, since the beginning of the betterment work on the Santa Fe, articles * have appeared in the technical papers or in the proceedings of different associations describing the progress of the work or considering some of its various phases. "Betterment Briefs" is a collection of a number of articles and papers, prepared by Mr. Jacobs, together with editorial comments which appeared at the time of their publication. Most of the articles appeared in the AMERICAN ENGINEER and the *Engineering Magazine*. In addition, a large number of illustrations, not heretofore published, are included, showing various special tools, devices, etc., which have been developed in connection with the betterment work.

The contents, by chapters, is as follows: Commercial tool methods in railroad shops; improved devices for railroad shops; high speed steel in railroad shops; practical advice to college men; organization and efficiency in the railway machine shops, divided into five sections: I, specializing and centralizing the operations and equipment; II, the general aspects of standardization; III, centralization and balance of machine tool equipment on an entire railroad; IV, standardization of the small tool equipment; V, erecting shop economics; the relation between the mechanical and store departments; shop efficiency; the square deal to the railway employee.

The edition de luxe is the finest example of the bookmaker's art ever received by this journal. It is to be sincerely hoped that Mr. Jacobs has a second edition in preparation to meet the demand of all those who are interested in shop or motive power betterment.

* A list of the articles which have appeared in this journal may be found in a foot note in connection with Mr. Epler's article on "Betterment Work in the Car Department," in this issue.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF TYPES OTHER THAN THE PACIFIC AND PRAIRIE

TYPE.	ATLANTIC. (4-4-2.)										TEN WHEEL. (4-5-0.)					AMERICAN. 4-4-0)		
Name of road	U. P.	Erie	C. M. & St. P.	P. R. R.	N. Y. N. H. & H.	C. B. & Q.	Har. Lines	C. R. I. & P.	G. W. (Eng.)	P. R. R.	B. & A.	S. P.	D. L. & W.	N. Y. C.	C. & N. W.	C. R. R. of N. J.	D. L. & W.	L. S. & M. S.
Road number or class	21	537	951	2,760	F1	P3	A-81	1,019	40	2,512	1,916	2,317	1,012	2,099		852	955	Pony
Builder	Baldwin	Amer.	Bald.	Amer.	Amer.	Bald.	Bald.	Amer.	Gt. West.	Soc. Als.	Amer.	Bald.	Amer.	Amer.	Amer.	Amer.	Amer.	L. S & M.S.
When built	1906	1905	1907	1905	1907	1904	1905	1905	1906	1904	1908	1907	1905	1905	1907	1905	1905	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Comp.	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	24,281	23,860	22,200	23,300	24,670	21,400	23,560	24,700	25,036	19,530	31,000	36,570	35,100	31,000	30,900	23,120	23,710	15,700
Weight, total, lbs	209,000	206,000	204,119	200,500	200,000	196,600	196,000	191,300	166,880	164,000	208,000	203,300	201,000	194,500	179,500	161,300	151,200	126,600
Weight on drivers, lbs	110,000	115,000	105,966	117,200	105,500	101,200	105,000	107,100	88,704	87,850	158,000	160,000	154,000	148,000	135,500	111,300	100,000	85,100
Weight on trucks, lbs	53,000	52,000	52,353	52,500	48,000	54,200	45,000	42,400	40,096	41,250			47,000	46,500	44,000	50,000	51,200	41,500
Weight on trailer, lbs	46,000	39,000	45,800	30,000	46,500	41,200	46,000	40,800	38,080	34,900	155,800	43,300						
Weight, tender loaded, lbs	162,200	162,800	130,000	132,500	134,000	120,400	162,200	144,000	89,600	132,500		141,366	120,000	143,500	139,500	122,200	110,000	105,200
Wheel base, driving	7′ 0″	7′ 0″	7′ 6″	7′ 5″	7′ 3″	7′ 3″	7′ 0″	7′ 0″	7′ 0″	7′ 1⅛″	15′ 10″	13′ 10″	14′ 4″	15′ 10″	14′ 10″	8′ 3″	8′ 6″	9′ 0″
Wheel base, engine	27′ 10″	28′ 0″	32′ 2″	31′ 11″	28′ 2″	30′ 2″	27′ 7″	27′ 5½″	27′ 9″	28′ 6⅛″	26′ 10½″	25′ 10″	25′ 6″	26′ 10½″	25′ 10″	23′ 1¾″	24′ 5″	25′ 1¼″
Wheel base, engine and tender	58′ 5″	60′ 9″	66′ 9″	61′ 4″	56′ 1″	57′ 6¾″	58′ 2″	57′ 2″	53′ 6¼″	59′ 5″	59′ 3″	58′ ¼″	54′ ¼″	59′ 2″	57′ 9″	49′ 2″	51′ 5⅝″	48′ 4¾″
Diameter of drivers	81″	78″	85″	80″	79″	78″	81″	73″	80½″	80 5/16″	69″	63″	69″	69″	63″	69″	69″	63″
Cylinders, number	4	4	4	4	2	4	2	2	4	4	2	2	2	2	2	2	2	4
Cylinders, diameter	16″ & 27″	15½ & 26″	15″ & 25″	16″ & 27″	21″	15″ & 25″	20″	21″	14¼″	14.8 & 23⅝″	22″	22″	21½″	22″	21″	19″	20″	12½″
Cylinders, stroke	28″	26″	28″	26″	26″	26″	28″	26″	26″	25 3/16″	26″	28″	26″	26″	26″	26″	26″	20″
Valve gear, type	Wals.	Steph.		Steph.		Steph.	Steph.	Steph.	Steph.	Wals.			Steph.	Steph.	Wals.	Steph.	Steph.	Wals.
Steam pressure, lbs	200	220	220	205	200	210	200	185	225	227½	200	200	215	200	200	200	185	180
Boiler, type	Str.	E. W. T.	W. T.	Belp.	E. W. T.	E. W. T.	Str.	Str.	Belp.	Belp.	E. W. T.	W. T.	Str.	W. T.	E. W. T.	W. T.	Str.	W. T.
Boiler, smallest diameter	70″	70¾″	66″	65⅝″	68″	64″	70″	72″	58¾″	59⅝″	72½″	72″	74⅝″	70⅝″	66⅜″	62¼″	61 3/16″	50″
Boiler, height center	113″	111⅜″	114″	109″	110″	108½″	113″	108″	98″	106 5/16″	115″	102″	116½″	115″		113″		78″
Heating surface, tubes, sq. ft	2475.	3453.6	3008.	2680.2	3041.	3050.5	2475.	2227.6	1988.65	2435.7	3104.5	2788.	3156.3	3124.7	2808.4	1838.1	1947.9	1,326.
Heating surface, firebox, sq. ft	180.	181.1	168.	181.4	204.4	155.5	174.	161.8	154.26	181.1	203.3	206.	221.7	202.7	150.8	167.6	190.8	140.
Heating surface, total, sq. ft	2655.	3634.7	3194.	2861.6	3245.4	3206.	2649.	2389.4	2142.91	2616.8	3307.8	2994.	3378.	3326.7	2959.2	2005.7	2138.7	1,466.
Heating surface, superheater, sq. ft								338.										
Grate area, sq. ft	49.5	56.5	45.	55.5	53 5	44.1	49.5	44.8	27.07	33.9	54.9	32.1	94.8	54.93	46.27	81.6	87.54	21.
Firebox, length	108″	108⅛″	107″	111″	108⅛″	96⅛″	108″	96″	98½″	119⅞″	105⅛″	124″	126⅛″	108⅛″	102⅛″	122⅛″	126 3/16″	96″
Firebox, width	66″	75¾″	60⅛″	72″	71¾″	66½″	66″	67¼″	38½″	40	75¾″	37¼″	108⅝″	75¾″	65¼″	96¼″	100 1/16″	31″
Fuel, kind	Bit. coal	Bit. coal.	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Anth. coal	Bit. coal	Bit. coal	Anth. coal	Anth. coal	Bit. coal
Tubes, number firetube	297	388	268	315	347	264	297	173	250	139*	400	355	398	400	337	280	280	187
Tubes, number superheater								54										
Tubes, diameter, firetube	2″	2″	2¼″	2″	2″	2¼″	2″	2″	2″	2 1/16″	2″	2″	2″	2″	2″	2″	2″	2″
Tubes, diameter, superheater								3½″										
Tubes, length	16′ 0″	17′ 0″	19′	16′ 3″	16′ 10″	19′ 0″	16′ 0″	16′ 0″	15′ 2 5/16″	14′ 5¼″	14′ 11″	15″	15′ 3″	14′ 11″	16′ 0″	12′ 6″	13′ 4¼″	13′ 6½″
Tender, coal capacity, tons	10	16	10	12½	14	12	10	12		12½	12	2,940	10	12	10	12	10	10
Tender, water capacity, gals	9,000	8,500	7,000	5,500	6,000	6,000	9,000	7,000	3,500	5,500	8,000	7,000	6,000	7,000	7,500	5,000	5,000	4,300
Weight on drivers ÷ tractive effort	4.53	4.82	4.75	5.	4.27	4.7	4.48	4.2	3.7	3.5	5 10	4.37	4.38	4.77	4.38	4.8	4.22	5.4
Weight total ÷ tractive effort	8.6	8.63	9.20	8.6	8.10	9.2	8.35	7.8	6.64	8.4	6.70	5.57	5.72	6.27	5.80	6.95	6.4	8.1
T. E. × diam. drivers ÷ total H. S.	740.	513.	610.	650.	600.	518.8	717.	754.	943.	600.	647.	770.	717.	647.	655.	800.	765.	670.
Total heat. surf. ÷ grate area	53.8	64.3	70.50	51.6	60.50	73.	53.6	53.3	78.8	77.5	60.20	93.	35.6	60.5	64.	24.7	24.4	69.5
Firebox heat. surf. ÷ total H. S. %	6.8	5.	5.30	9.37	6.30	4.85	6.6	6.75	7.2	6.9	6.15	6.90	6.6	6.1	5.10	8.4	8.9	9.5
Wgt. on drivers ÷ total heat. surf	41.5	31.7	33.10	41.	32.60	31.5	39.6	44.8	41.4	33.6	51.	53.40	45.6	44.5	45.75	55.3	46.8	58.
Wgt. total ÷ total heat. surf	78.9	56.8	64.	70.	61.80	61.3	74.	80.	78.	62.6	67.	68.	59.8	58.7	60.50	80.5	71.	86.5
Total H. S. ÷ superheating heat. surf								7.08										
Cylinder volume, cu. ft	10.2†	8.93†	9.†	10.2†	10.40	8.3†	10.2	10.4	9.6	7.15†	11.40	12.30	10.9	11.4	10.4	8.6	9.5	5.7
Total heat. surf. ÷ cyl. vol	262.	408.	355.	280.	311.	387.	260.7	230.	223.	367.	288.	243.	311.	292.	287.	233.	224.	257.
Sup. heat. surf. ÷ cyl. vol								32.5	69.									
Grate area ÷ cyl. vol	4.83	6.27	5.	5.42	5.16	5.3	4.85	4.3	2.82	4.72	4.8	2.61	8.68	4.8	4.45	9.5	9.2	3.68
Reference in THE AMERICAN ENGINEER	1906 p. 308	1905 p. 287	1908 p. 37	1906 p. 73	1907 p. 471	1904 p. 212	1905 p. 154	1905 p. 329	1907 p. 57	1904 p. 203		1907 p. 481	1905 p. 407	1906 p. 59	1907 p. 247			1906 p. 293

* Serve tubes. † Equivalent simple cylinders.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF THE PACIFIC (4-6-2) AND PRAIRIE (2-6-2) TYPES

TYPE	PACIFIC													PRAIRIE				
Name of road	P. R. R.	N. Y. C.	N. P.	A. T. & S. F.	Erie	R. F. & P.	B. & O.	N. Y., N.H. & H.	C. B. & Q.	Mex. Nat.	A.T. & S.F.	Har. lines	A.T. & S.F.	L.S. & M.S.	C. B. & Q.	N. P.	G. N.	Wabash†
Road number or class	K 28	3565	2,175	1290	2,511	84	P	I 1	S1	420	1,251	p.141	1800	4,724	R5	2,378	J1	G1
Builder	Amer.	Amer.	Amer.	Bald.	Amer.	Bald.	Amer.	Both	.....	Bald.	Bald.	Bald.	Bald.	Amer.	Amer.	Amer.	Bald.	Both
When built	1907	1908	1906	1908	1905	1907	1906	1907	1906	1907	1905	1905	1906	1906	1906	1906	1906	1907
Simple or compound	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Comp.	Simple	Comp.	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	30,700	29,200	30,340	32,600	30,300	31,100	35,020	31,560	31,100	35,066	32,800	29,920	37,800	27,850	35,060	33,300	37,560	34,558
Weight, total, lbs	272,500	266,000	240,000	232,750	230,500	230,800	229,000	229,500	228,000	227,340	226,700	222,000	248,200	233,000	216,000	209,500	209,000	205,900
Weight on drivers, lbs	183,900	171,500	157,000	140,400	149,000	143,750	150,500	142,500	150,000	147,040	151,900	141,000	174,700	165,200	152,000	152,000	151,000	150,500
Weight on trucks, lbs	.....	.....	53,000	54,950	41,000	46,850	40,500	46,500	42,000	.....	35,800	37,000	31,300	26,000	25,600	.....	21,000	21,900
Weight on trailer, lbs	.....	.....	30,000	37,400	40,500	40,200	38,500	41,000	36,000	.....	39,000	44,000	42,200	41,800	38,400	.....	37,000	.....
Weight, tender loaded, lbs	143,800	164,000	141,350	165,200	163,000	350,000	147,000	134,000	148,200	142,660	.....	162,200	175,000	159,900	148,200	139,500	151,000	153,000
Wheel base, driving	13′ 10″	14′	12′ 0″	12′ 8″	13′ 0″	12′ 10″	13′ 2″	13′ 1″	12′ 10″	12′ 0″	13′ 8″	13′ 4″	13′ 8″	14′ 0″	13′ 4½″	11′ 0″	13′ 0″	13′ 4½″
Wheel base, engine	35′ 2½″	36′ 6″	33′ 5″	34′ 4¾″	33′ 8″	32′ 8″	34′ 3½″	33′ 5½″	32′ 9″	33′ 11″	34′ 0″	33′ 4″	33′ 9″	34′ 3″	30′ 8½″	28′ 11″	30′ 9″	30′ 8½″
Wheel base, engine and tender	67′ 3½″	67′ 11″	62′ 10″	65′ 2″	65′ 1″	61′ 11½″	66′ 3¾″	61′ 2″	64′ 3¼″	62′ 11″	66′ 1½″	63′ 10½″	65′ 0″	62′ 5½″	62′ 2¾″	57′ 3½″	63′ 8″	61′ [illegible]″
Diameter of drivers	80″	79″	69″	73″	74″	73″	74″	73″	74″	67″	73″	77″	69″	79″	69″	63″	69″	70″
Cylinders, number	2	2	4	2	2	2	2	2	2	4	4	2	4	2	2	2	2	2
Cylinders, diameter	24″	22″	16½″ & 27½″	25″	22½″	22″	22″	22″	22″	17″ & 28″	17″ & 28″	22″	17½″ & 29″	21½″	22″	21″	22″	22″
Cylinders, stroke	26″	28″	26″	28″	26″	28″	28″	28″	28″	28″	28″	28″	28″	28″	28″	28″	30″	28″
Valve gear, type	Wals.	Wals.	Wals.	.....	Steph.	.....	Steph.	.....	Steph.	Steph.	Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Wals.	Steph.
Steam pressure, lbs	205	200	220	160	200	200	225	200	200	220	220	200	225	200	210	200	210	210
Boiler, type	Str.	Conical	E. W. T.	Str.	Str.	Str.	Str.	Str.	W. T.	W. T.	W. T.	Str.	E. W. T.	E. W. T.	W. T.	E. W. T.	Belp.	E. W. T.
Boiler, smallest diameter	78″	72″	72¾″	72″	74⅝″	74″	72″	70″	70″	70″	70″	70″	76″	70″	70″	72⅛″	72″	70″
Boiler, height center	119″	.....	115″	114¼″	113½″	112½″	112″	110″	109¾″	109″	.....	113″	115″	114″	107⅜″	115″	108″	107⅞″
Heating surface, tubes, sq. ft	4243	3981.6	2667.	3202	3131.	3917.	3,234.6	3743.	3,732.	3,527.	3,402.2	2,874.	3,803.	3,678.	3,375.	2,105.	3,277.	3370
Heating surface, firebox, sq. ft	205	228.3	241.8	190	195.	190.	179.4	204.4	200.	186.	192.8	174.	217.	227.	200.	235.	210.	190
Heating surface, total, sq. ft	4448	4209.9	2908.8	3392	3326.	4107.	3,414.	3947.4	3,932.	3,713.	3,595.	3,048.	4020.	3,905.	3,575.	2,340.	3,487.	3560
Heating surface, superheater, sq. ft	.....	.....	.....	.....	763.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grate area, sq. ft	61.86	56.5	43.5	49.5	56.5	49′ 5″	56.24	53.5	54.	52.1	53.	49.5	53.8	55.	54.	43.5	53.15	54.25
Firebox, length	111″	108⅛″	96″	107⅞″	108⅛″	108″	108⅛″	108⅛″	108⅛″	113⅛″	108″	108″	107⅛″	108⅛″	108⅛″	96″	116″	108⅛″
Firebox, width	80¼″	75¼″	65¼″	66″	75¼″	66″	75¼″	71¼″	72¼″	66¼″	71¼″	66″	71¼″	73¼″	72¼″	65¼″	66″	72¼″
Fuel, kind	Bit. Coal	Bit. Coal	Bit. Coal.	Oil	Bit. Coal	Bit. Coal	Bit. coal	Bit. Coal	Bit. coal.	Bit. coal	Oil	Bit. coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	343	382	306	273	195	318	276	310	303	301	290	245	342	322	303	306	301	303
Tubes, number superheater	.....	.....	.....	.....	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tubes, diameter, firetube	2¼″	2″	2″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2⅛″	2¼″	2¼″	2¼″	2¼″	2″	2¼″	2¼″
Tubes, diameter superheater	.....	.....	.....	.....	5″	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tubes, length	21′	20′	16′ 9″	20′	20′ 0″	21′	20′ 0″	20′ 6″	21′ 0″	20′ 0″	20′ 0″	20′ 0″	18′ 10⅝″	19′ 6″	19′ 0″	13′ 3″	18′ 6″	19′
Tender, coal capacity, tons	11	14	12	33,009	16	12	15	14	13	12	3,300	12	14	15	13	12	13	15
Tender, water capacity, gals	7000	8000	7,000	8,500	8,500	6,000	7,000	6,000	8,000	7,500	8,500	9,000	9,000	8,000	8,000	7,000	8,000	7,700
Weight on drivers ÷ tractive effort	6.00	5.84	5.2	4.33	4.95	4.62	4.3	4.5	4.8	4.2	4.6	4.7	4.6	4.4	4.3	4.6	4.	4.35
Weight, total ÷ tractive effort	8.85	9.11	7.9	7.12	7.7	7.65	6.6	7.25	7.3	6.5	6.9	7.4	6.6	8.3	6.2	6.3	5.6	5.95
T. E. × diameter drivers ÷ total H S	550.00	550.00	720.	700.00	669.	560.00	760.	585.00	585.	632.	666.	755.	650.00	565.	677.	900.	746.	680.00
Total heating surface ÷ grate area	72.00	74.50	67.	68.50	58.7	82.90	60.5	73.50	71.3	71.2	68.	61.5	74.	71.	64.8	53.8	65.	65.70
Firebox heat. surf. ÷ total H.S. %	4.62	5.35	8.3	5.60	5.85	4.64	5.23	5.20	4.85	5.	5.35	5.70	5.4	5.8	5.34	10.1	6.0	5.32
Weight on drivers ÷ total heat. surf	41.50	40.70	53.8	41.50	45.	34.90	44.	36.20	38.	37.4	42.	46.5	43.5	42.	42.5	65.	43.5	42.20
Weight total ÷ total heating surface	61.20	63.10	82.5	68.50	69.5	56.10	66.5	58.20	58.	61.1	63.	73.	62.	61.	60.7	89.5	60.	58.00
Total H.S. ÷ superheating heat. surf	.....	.....	.....	.....	4.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cylinder volume, cubic feet	13.60	12.32	9.9*	16.00	12.	12.30	12.3	12.30	12.3	11.6*	11.6*	12.3	12.1*	11.7	12.3	11.2	13.2	12.32
Total heating surface ÷ cyl. volume	326.00	341.00	294.	212.00	277.	334.00	278.	321.00	318.	330.	3.10	248.	334.	335.	290.	209.	265.	290.00
Superheating heating surf. ÷ cyl. vol.	.....	.....	.....	.....	63.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grate area ÷ cylinder volume	4.55	4.58	4.3	3.10	4.7	4.03	4.56	4.20	4.39	4.54	4.55	4.	4.43	4.68	4.46	3.89	4.03	4.41
Reference in THE AMERICAN ENGINEER	1907 p. 267	1908 p. 164	1906 p. 411	1908 p. 112	1905 p. 172	1907 p. 407	1906 p. 257	1907 p. 431	1906 p. 300	1907 p. 70	1905 p. 454	1905 p. 154	1906 p. 435	1906 p. 204	1906 p. 300	1906 p. 392	1906 p.365	1908 p. 31

* Equal equivalent simple cylinders. † Designed for fast freight service.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

FREIGHT LOCOMOTIVES OF OTHER TYPES THAN THE CONSOLIDATION

TYPE	MALLET				SANTA FE 2-10-2		DECAPOD 2-10-0	MIKADO 2-8-2		12-WH'L 4-8-0	10-WHEEL 4-6-0			0-10-0	0-8-0	0-6-0		
Name of road	Erie	G. N.	B. & O.	G. N.*	P. S. & N.*	A. T. & S. F.	B. R. & P.*	N. P.	N. P.	N. & W.	T. & P.	C. & E. I.	C. P. R.	L. S. & M. S.	C. & O.	P. & L. E.	P. R. R.	B. & O.
Road number or class	2,600	L-1	2,400		98	900		W.	1,608	N1	375	289	D-10	M.	8	253	B-6	D-23
Builder	Amer.	Bald.	Amer.	Bald.	Bald.	Bald.	Amer.	Amer.	Amer.	Both	Amer.	Bald.	C. P. R.	Amer.	Amer.	Amer.	P. R. R.	Amer.
When built	1907	1906	1904	1907	1907	1903	1907	1905	1906	1907	1907-8	1905	1905-6	1905	1903	1906	1904	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Tan. comp.	Simple	Tan. comp.	Simple	Simple	Simple	Bal. comp.	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	94,800	71,600	70,000	57,760	60,000	62,800	55,350	45,000	46,630	40,163	38,400	31,000	33,300	55,300	41,000	44,100	36,100	29,740
Weight, total, lbs	410,000	355,000	334,500	288,000	288,000	287,240	275,000	271,000	261,000	200,000	197,000	191,060	190,000	270,000	171,175	178,200	170,000	161,080
Weight on drivers, lbs	410,000	316,000	334,500	250,000	235,000	234,580	248,000	207,000	205,000	168,000	165,000	145,260	141,000	270,000	171,175	178,200	170,000	161,080
Weight on trucks, lbs		19,000		18,000		23,420		30 300	26,000	32,000	32,000	45,800	49,000					
Weight on trailer, lbs		20,000		20,000		29,240		33,700	30,000									
Weight, tender loaded, lbs	167,700	148,000	143,000	152,000	162,000	158,500	162,000	148,500	177,800	116,600	132,867	120,000	123,700		121,160	121,300	132,500	85,000
Wheel base, driving	14′ 3″	10′ 0″		9′ 10″	19′ 9″	19′ 9″	19′ 0″	16′ 6″	16′ 6″	15′ 6″	14′ 10″	13′ 6″	14′ 10″	19′ 0″	13′ 7½″	12′ 0″	11′ 6″	11′ 0″
Wheel base, engine	39′ 2″	44′ 10″	30′ 8″	43′ 7″	35′ 11″	35′ 11″	28′ 4″	34′ 9″	34′ 9″	26′ 5″	26′ 4″	27′ 7″	26′ 1″	19′ 0″	13′ 7½″	12′ 0″	11′ 6″	11′ 0″
Wheel base, engine and tender	70′ 5½″	73′ 2¼″	64′ 7″	72′ 0¼″	67′ 4½″	66′ 0″	65′ 3½″	63′ 1″	63′ 1″	53′ 7″	55′ 9½″	55′ 8″	54′ 6¾″	54′ 5½″	45′ 8″	46′ 2½″	43′ 3¼″	40′ 9½″
Diameter of drivers	51″	55″	56″	55″	57″	57″	52″	63″	63″	56″	63″	62″	63″	52″	51″	50″	56″	52″
Cylinders, number	4	4	4	4	2	4	2	4	2	2	2	4	2	2	2	2	2	2
Cylinders, diameter	25″ & 39″	21½ & 33″	20″ & 32″	20″ & 31′	28″	19″ & 32″	24″	19″ & 30″	24″	21″	22″	15½″ & 26″	21″	24″	21″	21″	22″	19″
Cylinders, stroke	28″	32″	32″	30″	32″	32″	28″	30″	30″	30″	28″	26	28″	28″	28″	30″	24″	28″
Valve gear, type	Wals.	Wals.	Wals.	Wals.	Wals.	Steph.	Wals.	Steph.	Wals.	Wals.	Wals. ‡	Steph.	Steph.	Wals.	Steph.	Steph.	Steph.	Steph.
Steam pressure, lbs	215	200	235	210	160	225	210	200	200	200	210	225	200	210	200	200	205	180
Boiler, type	Str.	Belp.	Str.	Belp.	E. W. T.	W. T.	Conical.	E. W. T.	E. W. T.	W. T.	E. W. T.	W. T.	E. W. T.	W. T.	W. T.	Str.	Belp.	Wooten
Boiler, smallest diameter	84″	84″	84″	72″	78¾″	78¾″	80″	75¾″	75¾″	70″	70½″	64″	70⅜″	80⅛″	67″	80″	67¾″	70″
Boiler, height center	120″	120″	120″	116″	118″	118″	116″	118″	118″	112″	114⅝″	109″	113½″	115″	112½″	108½″	108″	105″
Heating surface, tubes, sq. ft	4,971.5	5,473	5,380	3,708	4,586	4,587	3,280	3,819	3,192	2,605	2,731	2,933.7	2,233	4,422.6	2,573	2,906	2,343.	1,476.67
Heating surface, firebox, sq. ft	343.2	230	220	198	210	209	255.5	209	245 †	173	200	160.7	180	197.	164	206	152.1	172.84
Heating surface, total, sq. ft	5,313.7	5,703	5,600	3,906	4,796	4,796	3,535.5	4,028	3,437	2,778	2,931	3,094.4	2,413	4,619.6	2,737	3,112	2,495.1	1,649.5
Heating surface, superheater, sq. ft					762								378					
Grate area, sq. ft	100	78	72.2	53.4	58.5	58.5	55.5	43.5	43.5	45	46.3	46.69	49.5	55.4	38.8	33.3	41.25	73.3
Firebox, length	126⅛″	117″	108¼″	116¼″	108″	108″	108″	96″	96″	99½″	99″	101⅞″	102⅝″	108⅛″	80″	120″	90″	110″
Firebox, width	114¼″	96″	96¼″	66¾″	78″	78″	73¾″	65¼″	65¼″	64½″	67¼″	66″	69⅞″	73¾″	70″	40″	66″	96″
Fuel, kind	Bit coal.	Bit. Coal.	Bit. Coal	Bit. Coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Anth. coal
Tubes, number firetube	404	441	436	301	391	391	404	374	372	242	326	278	266	447	351	430	3.25	220
Tubes, number superheater													22					
Tubes, diameter, firetube	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2″	2″	2¼″	2″	2¼″	2″	2″	2″	2″	2″	2¼″
Tubes, diameter, superheater													5″					
Tubes, length	21′	21′ 0″	20′ 10¼″	21′ 0″	20′ 0″	20′ 0″	15′ 6″	19′ 6″	16′6″	18′ 4⅞″	16″	18′ 0″	14′ 2⅞″	19′ 0″	14′ 0″	13′ 0″	13′ 10¼″	11′ 6″
Tender, coal capacity, tons	16	13	16	13	14	14	14	12	12	10	12	12	10	12	7	10	11	6
Tender, water capacity, gals	8,500	8,000	7,000	8,000	8,500	8.500	9,000	8,000	10,000	6,000	6.500	6,000	5,000	8,000	6,000	7,000	5,500	4,000
Weight on drivers ÷ tractive effort	4.32	4.4	4.75	4.34	3.91	3.75	4.47	4.6	4.38	4.20	4.30	4.67	4.24	4.86	4.15	4.04	4.7	5.4
Weight, total ÷ tractive effort	4.32	4.95	4.75	5.00	4.8	4.56	5.12	6.0	5.6	4.98	5.13	6.15		4.86	4.15	4.04	4.7	5.4
T. E. × diam. drivers ÷ total H. S	910.00	690.	700.	813.	712.	747.	812.	705.	855.	810.00	825.00	620.	4.24	625.	763.	710.	810.	940.
Total heating surface ÷ grate area	53.14	73.	77.3	73.	81.8	81.8	63.3	92.5	78.8	61.60	63.50	66.	870.	83.	70.5	94.	60.3	22.5
Firebox heat. surf. ÷ total H. S., %	6.46	4.13	3.92	5.05	4.38	4.34	7.2	5.18	7.12	6.25	6.80	5.18	48.6	4.25	5 98	6.6	6.08	10.5
Weight on drivers ÷ total heat. surf	76.90	55.2	59.5	63.9	49.	48.8	70.1	51.1	59.6	60.50	56.00	46.7	7.42	58.3	62.3	57.1	68.	97.3
Weight total ÷ total heating surface	76.90	62.	59.5	73.8	60.	59.8	80.3	66.9	75.5	72.00	67.00	61.6	58.5	58.3	62.3	57.1	68.	97.3
Total H.S. ÷ superheating heat. surf					6.3								78.5					
Cylinder volume, cubic feet	24.00	20.75	19.	17.1	22.82	17.9	14.6	15.8	15.8	12.00	12.30	8.93	6.39	14.7	11.2	12.	10.5	9.2
Total heating surface ÷ cylinder vol	222.00	275.	295.	229.	210.	268.	243.	255.	218.	231.00	236.00	346.	11.2	314.	245.	260.	238.	179.
Superheating heating surf. ÷ cyl. vol					33.4								215.					
Grate area ÷ cylinder volume	4.70	3.75	3 85	3.14	2.57	3.28	3.81	2.75	2.76	3.75	3.78	5.2	33.8	3.78	3.48	2.77	3.95	7.95
Reference in THE AMERICAN ENGINEER	1907 p. 341	1906 p. 371	1904 p. 237, 262	1907 p. 213	1907 p. 88	'03 p. 372, 398 1904 p. 176	1907 p. 133	1905 p. 367	1906 p. 392	1907 p. 444	1908 p. 77	1905 p. 97	4.43 1906 p. 165	1905 p. 330	1904 p. 184	1906 p. 346	1904 p. 384	1906 p. 257

* Builders' weights. † Combustion chamber 3′ long. ‡ 20 Walschaert and 20 Stephenson valve gear.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED IN ORDER OF TOTAL WEIGHTS

FREIGHT LOCOMOTIVES OF THE CONSOLIDATION OR 2-8-0 TYPE

Name of road	N. Y. S & W.	D. & H.	L. S. & M. S.	L. S. & M. S.	P. R. R.	Wabash	A. T. & S. F.	B. & O.	Har. lines	C. S. N. O. & P.	P. R. R.	C. N. O. & T. P.	C. B. & Q.	M. St. P. & S. S. M.	W. P.	C. R. I. & P.	C. P. R.	C. of G.
Road number or class	140	1,011	5,962	G-46	2,762	.....	1,950	2,503	C-187	.....	H 6 B	734	D4	445	.....	55D	M4	1,200
Builder	Bald.	Amer.	Amer.	Amer.	Amer.	Bald.	Bald.	Amer.	Bald.	Bald.	Bald.	Both	Amer.	Amer.	Bald.	Bald.	Shops	Bald.
When built	1906	1906	1906	1903	1905	1906	1908	1905	1905	1907	1905	1907	1903	1905	1906	1906	1904-6	1907
Simple or compound	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple
Tractive effort, lbs	54,100	49,690	45,677	46,500	45,700	42,600	44,000	41,100	43,299	43,300	42,000	44,100	42,500	37,300	44,100	39,600	36,800	34,000
Weight, total, lbs	260,100	246,500	232,500	230,000	220,000	214,500	212,400	208,500	208,000	207,000	204,470	203,600	202,600	201,500	201,330	198,600	186,200	163,390
Weight on drivers, lbs	232,700	217,500	207,000	203,000	198,000	189,600	183,200	185,900	187,000	182,000	181,170	182,000	179,200	174,000	186,330	177,300	163,700	143,290
Weight on trucks, lbs	27,400	29,000	25,500	27,000	22,000	24,900	29,200	22,600	21,000	27,000	23,300	21,600	23,400	27,500	15,000	21,300	22,525	20,100
Weight, tender loaded, lbs	161,900	152,400	149,600	148,000	140,500	.....	175,200	143,500	135,050	148,000	143,000	146,400	150,200	116,900	.....	140,300	121,400	119,610
Wheel base, driving	17′ 0″	17′ 0″	17′ 6″	17′ 3″	17′ 6″	15′ 9″	15′ 6″	16′ 8″	15′ 8″	16′ 0″	16′ 3″	16′	15 8″	17′ 0″	15′ 8″	17′ 0″	15′ 10″	16′ 0″
Wheel base, engine	26′ 6″	25′ 11″	26′ 5″	26′ 5″	26′ 5″	24′ 6″	24′ 6″	25′ 7″	24′ 4″	24′ 4″	34′ 9″	24′ 3½″	24′ 6″	25′ 11″	24′ 4″	26′ 0″	24′ 4½″	24′ 3½″
Wheel base, engine and tender	60′ 10″	57′ 7½″	60′ 9½″	57′ 9¾″	60′ 3¾″	57′ 10½″	58′ 5″	59′ 8¼″	55′ 11¾″	56′ 3″	58′ 1½″	56′ 7¼″	69′ 1¾″	55′ 8½″	57′ 11½″	58′ 0″	53′ 4½″	53′ 9″
Diameter of drivers	63″	57″	63″	58″	63″	58″	57″	60″	57″	57″	56″	56″	57″	63″	57″	63″	57″	56″
Cylinders, number	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cylinders, diameter and stroke	28″ × 32′	23″ × 30″	23″ × 32″	23″ × 30″	23″ × 32″	22″ × 30″	24″ × 32″	22″ × 30″	22″ × 30′	22″ × 30″	22″ × 28″	22″ × 30″	22″ × 28″	23″ & 35″ × 34″	22″ × 30″	23″ × 30″	21″ × 28	20″ × 28″
Valve gear, type	Wals.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.	Wals.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.
Steam pressure, lbs	160	210	200	200	200	200	160	205	200	200	205	200	210	210	200	185	200	200
Boiler, type	Str.	Wooten	Rad. stay	W. T.	Str.	W. T.	Str.	Str.	Str.	Str.	Belp.	Str.	Str.	E. W. T.	Str.	E. W. T.	E. W. T.	W. T.
Boiler, smallest diameter	84″	83¾″	81⅝″	80″	80″	77″	78¾″	74′ 5″	80″	78″	71″	76⅛″	79½″	67⅜″	80″	74″	69″	61″
Boiler, height center	120″	113″	118¼″	119½″	117″	.....	114″	118″	114″	115½″	108¼″	114⅞″	115″	115″	.....	117″	111½″	105⅜″
Heating surface, tubes, sq. ft	3,931	3,716	3492.18	3,725	3,600	3,053	2,773	2630.1	3,226	2,939	2675.9	3,051	3511.56	2407.5	2,927	2,427	2,216	2069.3
Heating surface, firebox, sq. ft	198	329.5	213.05	232	182	192	157	179.3	177	183	166.5	175	221.77	158.	214	168	165	140.
Heating surface, total, sq. ft	4,129	4045.5	3705.23	3,957	3,782	3,245	2,930	2809.4	3,403	3,122	2842.4	3,226	3733.33	2565.5	3,141	2,595	2,381	2209.3
Heating surface, superheater, sq. ft	834	.....	.....	.....	.....	.....	600	.....	.....	.....	.....	.....	.....	261.4	.....	.....	375	.....
Grate area, sq. ft	60.2	99.85	56 5	55	55.4	50.4	47.4	56.24	49.5	51	49.11	54	54.2	46.8	33.6	50	43	44
Firebox, length	120″	126⅛″	108⅛″	108″	106″	108¼″	95½″	107⅝″	108″	108″	107″	108″	108⅜″	96⅛″	121″	107″	96⅝″	96⅛″
Firebox, width	72¼″	114″	75¼″	73¼″	75¼″	67¼″	71¼″	75¼″	66″	68″	66″	71¾″	72″	70¾″	40″	67¼″	65¾″	66″
Fuel, kind	Bit. coal	Anth. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	472	493	446	461	446	360	355	282	413	386	373	403	450	224	390	340	244	283
Tubes, number superheater	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40	.....	.....	22	.....
Tubes, diameter, firetube	2″	2″	2″	2″	2″	2¼″	2″	2¼″	2″	2″	2″	2″	2″	2″	2″	2″	2″	2″
Tubes, diameter, superheater	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3½″	.....	.....	5″	.....
Tubes, length	16′	14′ 6″	15′	15′ 6⅛″	15′ 4¾″	14′ 6″	14′ 11″	15′ 10″	15′	14′ 6½″	13′ 8½″	14′ 6½″	15′	15′ 9″	14′ 5″	15′ 6″	14′ 1⅜″	14′ 8″
Tender, coal capacity, tons	15	14	12	16	13½	.....	3,300 G	15	14	12	13½	12½	14	10	14	12	10	8
Tender, water capacity, gals	9,000	7,800	7,500	7,500	7,000	8,000	8,500	7,000	7,000	7,500	7,000	7,500	8,000	6,000	8,000	7,000	5,000	6,000
Weight on drivers ÷ tractive effort	4.3	4.37	4.5	4.37	4.3	4.44	4.17	4.5	4.3	4.2	4.3	4.13	4.2	4.65	4.2	4.5	4.4	4.2
Weight, total ÷ tractive effort	4.8	4.97	5.0	4.95	4.8	5.	4.75	5.1	4.8	4.76	4.8	4.61	4.8	5.4	4.55	5.	5.1	4.8
T. E. × diam. drivers ÷ total H. S	825.	709.	775.	680.	760.	760.	855.	875.	725.	790.	830.	768.	650.	830.	800.	965.	800.	860.
Total heating surface ÷ grate area	68.50	40.5	65.8	72.	68	64.	62.	50.	69.	61.	58.	59.80	69.	55.	93.	52.	55.	50
Firebox heat. surf. ÷ total H. S. %	4.80	8.12	5.75	5.85	4.82	5.9	5.35	6.35	5.2	5.85	5.9	5.42	5.9	6.15	6.8	6.5	6.9	6.3
Weight on drivers ÷ total heat. surf	56.	53.5	55.8	51.2	52.	58.	62.50	66.	55.	58.2	63.5	56.40	48.	48.7	59.5	68.	69.5	65.
Weight total ÷ total heating surface	63.	60.8	6.25	58.	58.	66.	72.50	74.	61.	66.	72.	63.	54.	56.5	64.	77.	78.	74
Total H. S. ÷ superheating heat. surf.	5.	.....	.....	.....	.....	.....	4.90	.....	.....	.....	.....	.....	.....	9.85	.....	.....	6.35	.....
Cylinder volume, cubic feet	22.70	14.4	15.4	14.4	15.4	13.2	16.80	13.2	13.2	13.2	12.4	13.20	12.4	11.4*	13.2	14.4	11.2	10.2
Total heating surface ÷ cyl. volume	181.	280.	242.	275.	246.	246.	174.50	213.	259.	236.5	229.	244.06	302.	312.	238.	180.	213.	217.
Superheating heat. surf. ÷ cyl. vol	36 8	.....	.....	.....	.....	.....	35.5	.....	.....	.....	.....	.....	.....	23.	.....	.....	33.3	.....
Grate area ÷ cylinder volume	2.65	6.92	3.66	3.8	3.6	3.8	2.82	4.3	3.75	3.87	3.95	4.10	4.4	4.1	2.55	3.48	3.8	4.3
Reference in THE AMERICAN ENGINEER	1907 p. 302	1907 p. 22	1906 p. 263	1903 p. 415 1904 p. 11	1906 p. 73	.....	1908 p. 112	1906 p. 31	1905 p. 154	1907 p. 194	1906 p. 231	1908 p. 26	1903 p. 48	1905 p. 150	.....	1907 p. 147	1906 p. 165	1907 p. 31

* = Equivalent simple cylinders.

STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

THE UNDERFRAME.—PART IV.

Synopsis.

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Form I.

The total resisting moment of the plate girder is composed of the separate resisting moments of its component members, and not as if the whole were considered a homogeneous unit. Thus this total moment would equal the resisting moments of the two side sills plus that of the two center sills, plus that of the web plate. These can all be reduced to statical moments. The last term involves the moment of inertia from which the area can be separated, leaving it similar in form to the first two.

This has been thus far a preliminary investigation which makes no allowance for the effect of rivet holes in the plate along the transverse supports. Final calculations should be based upon net area. The joints of the ends of adjacent plates at the transverse supports must be examined carefully, so that they are as strong as the plate for the shearing and bending stresses in the web. The shearing stresses have been considered as uniformly distributed, but the moment stresses are not, as they range from 0 at the neutral axis to a maximum at the edge of the web. Hence, having found the moment to be resisted by the web it is required that the riveting be considered as resisting directly as the square of the distance of its center from the neutral axis. This shows the good office fulfilled as far as strength goes by a joint with the riveting most compact near the edge of the plate. If joints, where necessary, are made to come at the transverse supports the lines of riveting will here conserve two functions—one as outlined above and the other to secure the web stiffeners. A plate girder covering the whole floor is somewhat deeper than the economical depth when using ⅛ inch sheets. A sheet of 3/32" plate will give about the lightest construction possible for this type of design with a side sill area of 9 square inches. The plate girder cannot be built as light as the trussed girder, but it is more reliable and affords excellent opportunity for building the floor of the car directly upon it.

The Side Girder.

The transverse supports must have a minimum deflection and deliver their concentrated loads direct to the side girder at a body post, for a minimum bending moment in this girder.

This side girder is composed of the side sill angles as a bottom chord and the belt rail as a top member. In some cases, however, this has been deepened to the side eave. Such construction requires careful investigation as the opportunity for binding of windows is very great. The plates on the sides are required to take up the vertical shears and the diagonal shears set up by the tension and compression. Any window frames set into this plate must be strong enough to sustain these loads and to make up for decreased strength of the web.

The resisting moment for the side girder is of the same form as for the floor girder, except there is no central resisting member.

The value of the stress to allow for the various members may be obtained from the assumption of the maximum deflection permissible under full load and then equating the beam for strength and stiffness and solving for the consequent stress. This stress in no member should be allowed to exceed half the elastic limit of the material. This means that the beam must be designed so that when the side thrust from end shock comes upon the side sill there is reserve strength sufficient to keep it below this figure.

This low stress is necessary, due to the fact that the girder is loaded upon the tension member and the stiffening of the compression member against lateral buckling is a difficult matter. This must be accomplished by means of the posts and carlines which must necessarily be very light for this form, to save weight. The beam lies somewhere between the condition of one with an unbraced top chord and one with it rigidly fastened. The character and cross bending strength of the posts determine to which case it is most nearly analogous.

If it were possible, the flooring should be attached to the compression member and this itself would then prevent the destructive torsional action of the beam. Any construction, therefore, which makes the top chord a tension member for a considerable portion of its length, decreases this tendency. The decrease in the twisting is not directly as the decrease in length of the top compression flange, but as the square of the length. This result was proven by the experiments of Mr. A. E. Guy, wherein he showed that, "the load at which such a beam would buckle sideways is that load which would buckle the same beam if it were placed vertically and thereby converted into a strut."

The character of the curves of moment on the side girder will follow the character of the forms shown in Fig. 3.

Salient Points.

This type of underframe finds its most profitable field of usefulness in service at nominal end shocks and with cars not having side entrances other than at the platforms.

Here the direct resisting members are so weak that they are capable of absorbing but a portion of any fair-sized end shock, and are not suitable to sustain even their own weight without

Errata, Form I.—The weights of trailer cars (70,000) and motor cars (75,000) given on page 83 should read 75,000 and 100,000 respectively.

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undue deflection. It is hence necessary that the strains beyond the limits of capability of the center sills be provided for by the balance of the framing. This can be accomplished as follows: For any transverse horizontal movement of the sills a resisting girder can be formed of the floor construction; for any vertical movement of this floor girder a resisting girder can be provided by the construction of the sides of the car.

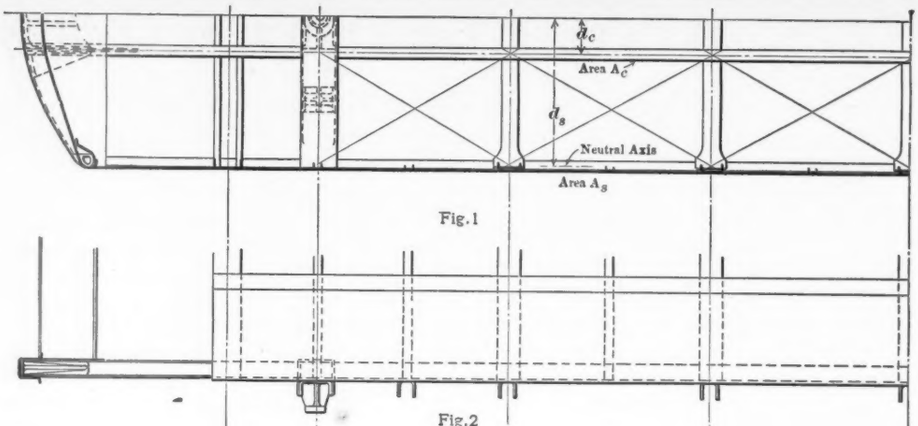


Fig.1

Fig.2

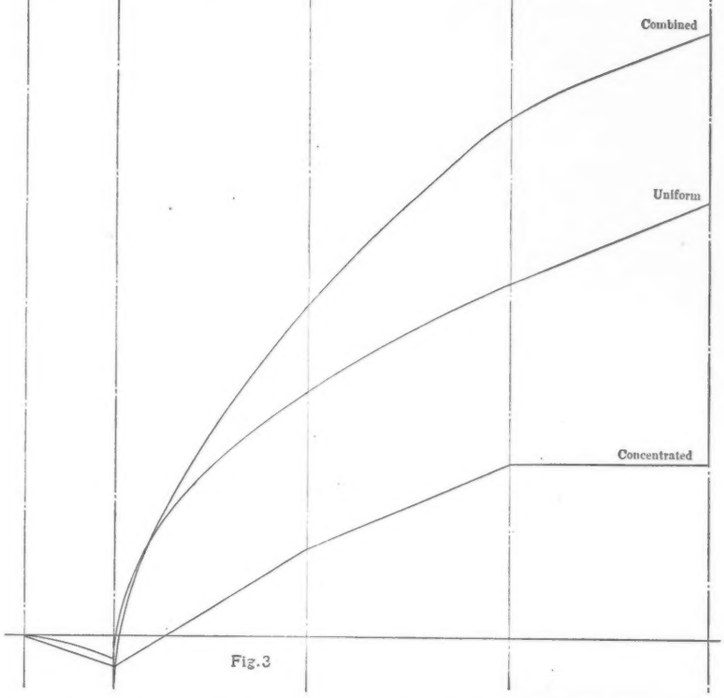


Fig.3

The side girders are load carriers in a vertical plane and should be capable of taking all the center sill forces transmitted to them by the transverse supports. These loads to be provided for will be the reactions at the points of support of the center sills. These reactions are due to the dead and live lading and the uniform lading equivalent of the end shock. This beam is of the nature of a plate girder of overhanging ends with a uniform dead lading of superstructure and portion of uniform live lading (see p. 12, January issue, Fig. 8), together with the concentrated loading transferred from the center sills.

The floor girder utilizes the side sills and the center sills either by forming a trussed or a plate girder to provide for horizontal bending tendencies of the center sills. The loads coming upon this girder are different for the two types of girders, due to the different character of the reinforcement.

With a stiff floor girder the tendency is toward a downward and not a horizontal deflection, this increases the vertical reactions transferred to the side sills.

The center sills fulfil the conditions of a continuous beam in both vertical and horizontal planes and have, besides the combined flexural stress, a direct stress due to the static end load.

The distinguishing difference between the trussed and plate girder may be noted when the whole floor of the car is considered as a unit taking end shocks. These are imposed directly upon the end of the center sills which in the trussed girder bend locally between the transverse supports. The plate girder prevents this bending and then the center sills are but compression pieces for concentric end shocks.

Following this, the whole floor acts as an end loaded beam, the span of which is the distance betwen truck centers and the remainder overhanging, and would deflect as such. The equivalent side load for end shock is solved similarly to the above cases where the resisting moment is known.

The underframing of the light car just considered for metropolitan and interurban motor car train service, is a direct evolution by various stages from the car which had the buffers and pulling eye fastened upon the platform end sill. Service damage acting as an indicator of points of weakness caused the introduction first of platform sills running back to the bolster, then of a single sill between the bolster and finally a number of longitudinal sills throughout the length of car.

In effect, these sills all carried loads and could be made quite light by the use of truss rods and needle beams. The use of steel showed the possibility of a much stronger side girder and the elimination of the intermediate sills. Removing the truss rods from the center sills the side girder was made to serve the same purpose by the introduction of transverse supports at more frequent intervals than the needle beams. Form I. is thus a direct step in the evolution from wood.

The method of providing for the lading and end shocks of service as found in Form II. is a more radical departure. The field of possible arrangement of underframe members was considered and the study carefully worked out with the fact that the material to be used is much more efficient than wood, and at the same time less elastic.

FORM II.

General Theory.

The general theory upon which this form bases its claims may be concisely stated as, "the production within the center sill members of interior opposing forces whose tendency is to neutralize and leave a minimum of forces of translation or rotation for which provision must be made." Coupled to this is the theory, "that whatever translation does occur the connections between the longitudinal load and shock carriers should not cause this moment to destroy the alignment of the superstructure carrier."

The first of these theories will be found to have been discussed in the first underframe article (December issue); the second will be dealt with here under the effects of side sill supports being upon different levels.

Definition.

Quoting from page 461 (December issue): "The second form is readily known by the absence of any bolster. This is its distinguishing characteristic. In this case the static lading is all transferred at various intermediate points to the center sills which in turn put it directly upon the center plates riveted to them. This type presupposes a strong center sill and may make use of a weaker side girder."

Inquiries upon the subject lead us to believe that but one railroad is using this form and that the various car companies are

building these cars but for the Pennsylvania Lines. The size of the order (200 cars) now being completed and the money represented by such an order are indisputable proof of the belief in its distinguishing features. In addition to this order is the one now building for the Long Island Railroad of 50 coaches of the same form of underframe for suburban steam service and to be ultimately used for multiple unit control. This underframe is shown in Fig. 4.

The underframes as represented in these two orders give every form that is needed for present steam operation with considerations for electricity as noted in our previous articles.

FIELD OF USEFULNESS.

Service.—For trunk line operation using steam or electric locomotive propulsion either in accommodation or express service, this underframe is best adapted. Also for suburban service where the liability of contact with the strong steel freight or express trains is probable.

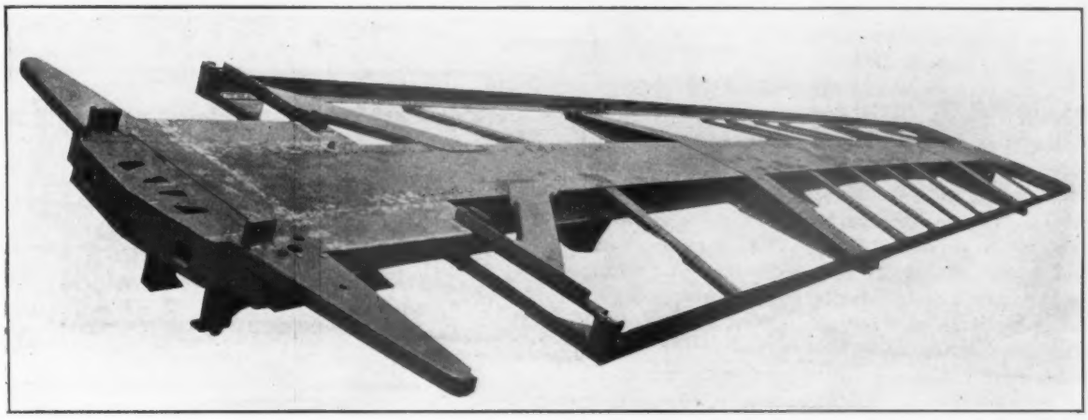


FIG. 4.—UNDERFRAME OF STEEL SUBURBAN CARS FOR THE LONG ISLAND RAILROAD.

The only service for which it cannot be said to be the best form is that for separate car running and the service for which Form I. is adapted, and even this conclusion is open for argument.

Types of Cars.—The variety of cars lending themselves to design upon this underframe is a range of all the types now being built except possibly the side entrance car with a central door—all other arrangements of side doors can be used and make use of its economical principles.

The central entrance side door causes trouble with the second theory, since the deflection at this point is more than at the other points of transverse support connections. The disadvantage of having unequal deflections at the points of superstructure carrying and the harm caused by such difference is dealt with in detail later in this section.

	Length over body end sheets	Truck	Capacity	Weight in pounds*
Passenger Coach	70′ 5½″	4 wheel	88 pass.	113,500
Postal	71′ 4½″	6 "	50,000 pounds	129,000
Baggage Express	60′ 10½″	4 "	35,000 pounds	91,000
Passenger Baggage	70′ 0″	6 "	44 pass. 25,000 pounds	130,000
Dining	71′ 11¾″	6 "	30 pass.	140,000
Suburban Passenger	54′ 4″	4 "	72 "	75,000
Suburban Passenger Baggage	54′ 4″	4 "	54 pass. 15,000 pounds	75,000

* Estimated Weights.

Cars of this type now building are given in the above table.

FACTORS OF DESIGN.

The available depth of underframe is limited by two considerations—the height of floor and truck clearance. To clear a standard truck with a center plate of minimum thickness on the bottom of the sills, the bottom would have to be 26¾″ from the rail. An examination of the Pennsylvania cars using their standard steel trucks as illustrated in the AMERICAN ENGINEER in June and July, 1907, shows that by making a special truck with a depressed end truck rail this has been reduced to 29½″. This shows a gain in available space of 7¼″, but contrasted with the wooden equipment this is not as large as it should be, for the reason that the space taken by the bolster running underneath the sills is not considered. This dimension would add to the above for increased possible depth.

The floor and side sill heights should be approximately the same. The detail construction of the flooring will determine whether the tops of the wood and steel center sills are in alignment. The advantage in not using the bolster shows a gain in depth of 11″ for the cars of this type now running. For motor cars the depressed truck rail is not required as the motor case governs the clearance, and this has been stated in the article on Form I. to be 41″.

The steam or electric locomotive service thus permits an additional depth of 11½″ over and above that for multiple control with the same floor conditions. This great available center sill depth is the feature which permits the design to be built according to the economic theory advanced. To resist impact and inertia forces, area in the longitudinal members is necessary. To a greater degree than in any other form of underframe does this type place the area directly in the line of action of the forces of collision.

The American steel manufacturers in opposing the demands of the recent rail specifications of the railroads have brought great pressure to bear upon the question of the destructive influences of the maximum wheel loads at high speeds. The axle lading is then a factor of design whose lessening is a matter of much import. They should not in any case be allowed to increase beyond what is now found. This will be seen to be a very important feature, when it is considered that the intensity of the blow struck upon the rail is a function of the square of the velocity. For this reason it is very probable that a train of steel passenger cars may have a more deleterious effect upon the track than a slower train of heavier wheel loaded freight cars.

This form of underframe requires a truck of special design, if for no other reason than that of the side bearings. The absence of any bolster necessitates the placing of such bearings upon the side sill angles, which gives them a spread wider than is customary. The truck side bearing must come out to meet them and must rest upon a flexible base such as a spring supported swing bolster. This is necessary to secure easy riding and to prevent the frictional resistance to turning of the truck from causing the wheel flanges to override the rail and cause derailment.

The proper spacing of side bearings is a debatable question even in wooden equipment. They now vary from 48″ to 60″. Not alone the spacing, but the character is open to dispute. Friction or frictionless bearings have their able advocates and the same problem with the same divergency of opinion will follow into the steel car. The question bears added weight in the new construction, the flexibility of the car being less and the chattering action being more noticeable.

Weight Limitations.—The theory upon which this design is based makes it a most economical solution to the problem where destructive end shocks must be considered. Economical in so far as weight is concerned as well as material and productive labor. Maintenance and depreciation costs should be very low; repair after an accident will require but minimum effort since the parts sustaining damage are few and these can be designed so that structural shapes could be substituted for original pressed pieces if necessary.

Depreciation costs dwindle because the whole resistance is made compact and of the best form to stand the constant racking of service. The underframe of a 70 ft. car to stand up under the requirements of specifications, should be built to weigh but 25,000 pounds.

Reliability and economy are associated terms. The framing elements afford their intended security when the sum total stresses do not exceed the specified limits and the weight, and hence the sectional area, must be as small as possible and still keep within these limits. The greatest reliability is obtained when the unknown factors of strain are reduced to a minimum and the loads must be taken by the framing as intended. This result is very closely approximated by this type, as the framing permits of but one manner of load acceptance—through the center sills. Hence, knowing the external forces, this underframe is perhaps the nearest approach to engineering exactitude of any.

For the progress of the art it is well that the introduction of steel equipment should oppose adverse conditions as far as competition with wooden equipment is concerned. The future may produce a car which makes of the whole platform a "concussion buffer—*i. e.*, the car between body end sheets will be formed as an exceeding strong longitudinal and vertical unit and the platform designed so as to have a crippling strength weaker than the main car framing. The idea is to have the platforms separate from the car framing and depend upon the ultimate resilience of the platform in crushing to absorb a large portion of the destructive kinetic energy and thus leave but a portion of it to be absorbed by the elastic resilience of the main framing.

In this connection the platforms must be framed capable of sustaining more than the combined capacities of the buffers and the draft gear. On the other hand, they should not approach the strength of the main body framing so closely as to seriously endanger the crippling of these members simultaneously with the platform itself. The platform then, to conserve the purpose outlined, would occupy a position of strength intermediate between the buffing attachments as a lower limit and the specified stress allowed in the body framing for security. Interchangeability should be a feature of this detail platform. It should be designed so that its attachment to the body of the car would facilitate the exchange of a damaged end by a new one if necessary.

Center Sill Lading.—The strains coming upon the individual members of the framing have been dealt with, in so far as the center sills are concerned, in the article illustrating the graphical analysis in the January issue. This article in general assumed any number of transverse supports, showing one (P_4) in the mid region. The most economical underframe would omit this unless the superstructure arrangement required it, and the curves would be altered accordingly. The center sills are then acting under maximum strain as a side loaded column—side loaded both uniform and concentrated. The center sills, being wider than deep, afford greatest resistance to bending in the horizontal plane and leave the transverse supports for the side girder in the condition of double cantilevers. The base of these should be large to afford sufficient attachment at the center sills and side sills for preserving their normal perpendicularity and successfully resisting the tendency of inertia forces from carrying the superstructure beyond the underframe.

In this connection the use of diagonal end struts to carry body corner blows to the center sills should be given consideration.

The ties between the side and center sills other than the cantilevers should be light and not capable of vertical load transference. This would defeat the purpose of the design.

Between supports the two sets of longitudinal sills (side and center) should be capable of independent deflection.

The elimination of auxiliary draft sills is a noticeable feature of the platform end of this underframe. The eccentricity of resultant end shock action can be reduced to zero if desired, but this does not secure an opposition of bending moments at the center of the car as is very desirable and can only be obtained when the resultant is below the neutral axis.

Another region of great stress activity is over the center plate and additional cover plates may be required to provide for it at this point.

Vertical Superstructure Movement.—The value of preserving the same vertical deflection of the points of supports of the side sills is most prominently illustrated by the following considerations:

The side girder is in the condition of a continuous beam of three spans and four supports; the general formula

$$M_n l_n + 2M_{n+1}(l_n + l_{n+1}) + M_{n+2} l_{n+2} = \frac{W_n}{4} l^3_n + \frac{W_{n+1}}{4} l^3_{n+1}$$

previously worked out for continuous beams will hold true only for those beams whose supports remain in the same horizontal plane. If such be not the case, the latter term of the equality will

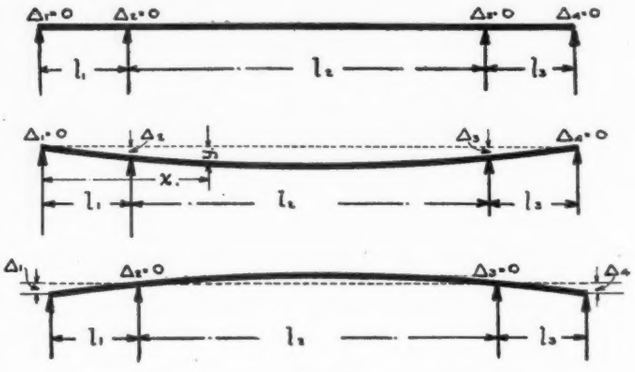


FIG. 5.

be larger than given by an amount depending upon the ratio between the difference in elevation of the ends of a span to its length multiplied by six times the product of the modulus of resistance and elasticity.

These points will remain in the same horizontal plane so long as the transverse supporting cantilevers have a uniform strength or deflection and their points of attachment to the center sills have the same vertical movement due to the deflection of the center sills.

The difference in elevation of the three supports for two spans enters into the problem just as the moments at the three supports enters into the moment formula.

The accompanying illustration (Fig. 5) shows clearly the general cases which may arise in practice from a neglect of the foregoing considerations.

The first diagram shows a continuous beam of three spans of lengths (l_1, l_2, l_3) and four points of support upon the same level. The deflections at the points of support are here zero in each case. To this figure the general formula given above is applicable.

The second diagram shows the mid supports depressed. This condition could happen very easily if the buffing loads do not act to counterbalance the dead and live lading. In this case the relation between x and y is quite different from that used in finding the value of the constant of integration for the tangent equation of the elastic curve from which the given moment relation is deduced. Instead of $y = o$ for all values of x to the supports

$y = o$ when $x = o$
$= \triangle_2$ " $x = l_1$
$= \triangle_3$ " $x = l_1 + l_2$
$= o$ " $x = l_1 + l_2 + l_3$

This diagram shows how the girder may approach the condition of uniformly loaded simple beam and be compelled to assume strains for which it has not been designed. The car will eventually take a permanent downward set in the center and hence appear much weaker than it really is.

The last diagram shows the end sills to have gone down the most. The relations between x and y change in this case as before and are found to be $y = \triangle_1$ when $x = o$

$= o$ " $x = l_1$

$= o$ " $x = l_1 + l_2$

$= \triangle_3$ " $x = l_1 + l_2 + l_3$

Here the girder approaches to that of a uniformly loaded beam with both ends overhanging. The car is liable to list downward at the end sills. This is the same condition which is noticeable in so many dining cars at the kitchen end. These changed relations alter the formula noted above to read

$$M_n l_n + 2M_{n+1}(l_n + l_{n+1}) + M_{n+2} l_{n+2} = \frac{W_n l^2_n}{4} + \frac{W_{n+1} l^3_{n+1}}{4} - 6EI\left(\frac{\triangle_{n+1} - \triangle_n}{l_n} + \frac{\triangle_{n+1} - \triangle_{n+2}}{l_{n+1}}\right)$$

The effect is really cumulative in that the action tends to increase the deflection of center sills in the locality of the highest support and the operation thus juggles back and forth until a state of equilibrium is reached.

Following the tendency in freight car design of fish bellied pressed steel sills the Pressed Steel Car Company used these upon the Southern Railroad coach (AMERICAN ENGINEER, July, 1906, p. 260). These sills may be used in this form of underframe, but are open to the disadvantage that as the belly deepens the neutral axis lowers, and with a deep sill the conditions as to underhung resultant draft gear may change and the effect sought after in making the buffing oppose the lading moment, be lost. The use of top cover plates will preserve the axis nearer to the upper surface. The bow is helpful in that it permits the spacing of the cantilevers and end sill almost at will with the supporting truck center. This advantage is of much value in the design as it means the elimination of the greatest of the numerous limitations governing superstructure arrangement.

This valuable feature is a result of the change in modulus of resistance of the section. For any beam of whatever character the deflection is a direct function of the load into the cube of the span and the inverse function of the product of the modulus of resistance and moment of inertia. Thus the deflections can be equated for the various points of support and the relation between the values of the required modulus of resistance at the various points deduced. The value of I then governs the deflection and the bellying of the sills will secure the result.

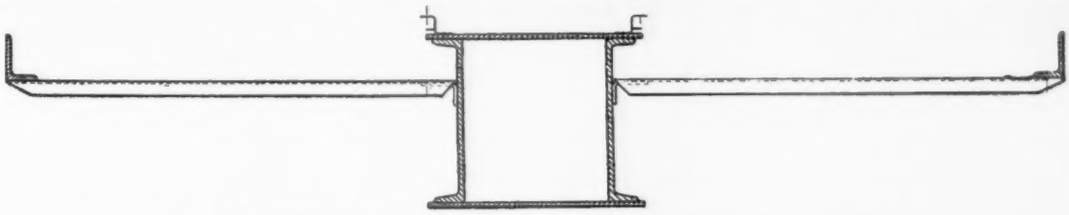


FIG. 6.—SECTION THROUGH FORM II. UNDERFRAME BETWEEN CANTILEVERS.

With a box girder this is accomplished by the use of additional cover plates and the preservation of the relation between the line of action of the end shock and the neutral axis of the center sill section, is much improved over that for the pressed sills.

ANALYTICAL ANALYSIS.

The principles underlying the solution of any case of Form II. were given on pages 15 and 16 (January issue), based upon diagrammatic figure on page 13. These principles are fundamental and apply to all forms. In the table given below, however, the value of $\frac{L}{2}$ has been substituted for X in the column of forces, since this will give the maximum value of M_x.

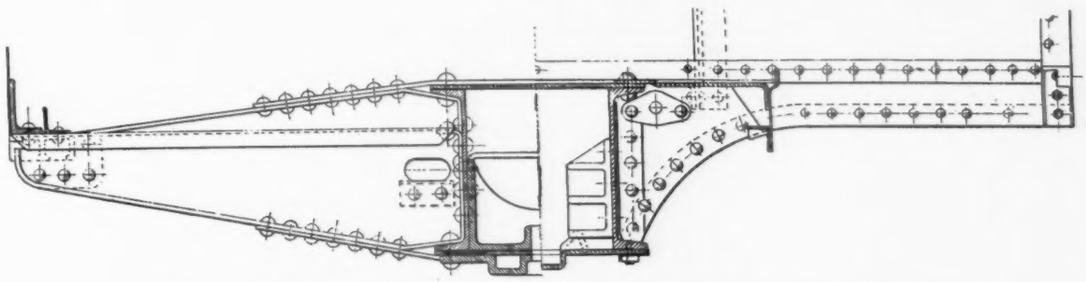


FIG. 7.—SECTION THROUGH FORM II. UNDERFRAME AT CANTILEVER AND AT PLATFORM.

The most economical design of this underframe demands the omission of the central cantilevers and hence the concentrated load coming upon the center sills, as at P_4 in the former case, will not be found in this case. The table, as altered to suit these conditions, which will apply to an underframe of the type shown in Figs. 6, 7 and 8, is shown in Fig. 9.

In substituting values of P_3 it must be remembered that in removing P_4 the value of P_3 is increased by the value of d covering what is now 2d + e. (See Fig. 11, page 13.)

The value of w here noted is the uniform side load equiva-

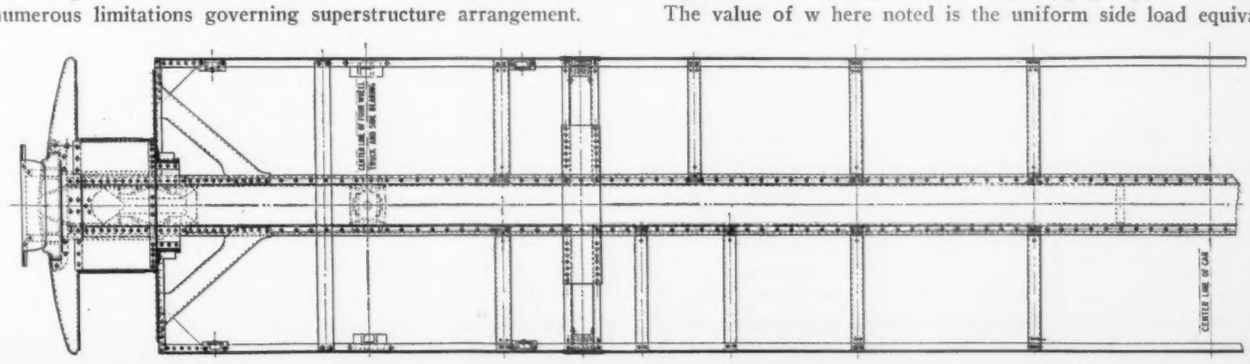


FIG. 8.—PLAN OF FORM II. UNDERFRAME.

lent of the end shock and is found from equating the end moments:

$$150{,}000\ (J + \Delta') = \frac{W}{2}\left(\frac{L}{2} + a + b\right)^2$$

The one approximation in this analysis is the assumption upon which the values of P are based. These are quite near to being correct without much calculation. To be precise, they are the reactions from the three span continuous side girder. The same remark will hold true in the graphical analysis and the moment curves at the center of the car will be reduced by the elimination of the central loads.

+−	Forces in pounds		Arm to section in feet	Bending moment in foot pounds
+	Reaction	$P_1+P_2+P_3+(\frac{L}{2}+a+b)(550+w)$	x	$P_1x+P_2x+P_3x+(w+550)(\frac{L}{2}+a+b)x$
−	Platform end sill	P_1	$x+a+b$	$-P_1x-P_1a-P_1b$
−	Body end sill	P_2	$x+b$	$-P_2x-P_2b$
−	Inter-Cantilerer	P_3	$x-c$	$-P_3x+P_3c$
−	Uniform centre sill Load	$550(\frac{L}{2}+a+b)$	$\frac{x+a+b}{2}$	$-275(x+a+b)(\frac{L}{2}+a+b)$
−	End shock Load Pulling	$w(\frac{L}{2}+a+b)$	$\frac{x+a+b}{2}$	$-\frac{w}{2}(x+a+b)(\frac{L}{2}+a+b)$

FIG. 9.

We have noted that the recommendation of a standard center sill area is not feasible if uniformity in strength is to be considered of more importance than uniformity in the sizes of beams for this element of the underframe. There is, however, a certain portion of the area of the box girder center sills which could be adopted as a standard and the desired result of uniform strength still be secured. The section of the structural beams could be thus specified and the increased resistance at the various sections to take care of the disturbing strains for increased car length or variety of lading be provided by the proper use of cover plates.

A study of the cars built for similar service conditions upon the various railroads yields no idea as to just what the general opinion of car designers would be in respect to the size of such area. The range as now in service extends from a little over 10 square inches to 55. This is a very wide variation. Probable 25 square inches in the channels or I beams would be most convenient to meet the requirements of strength as noted in our previous article upon end shock.

Uniformity in specifications for end shock and strength required at such a shock would seem to be necessary before uniformity in basic area could be secured. The one naturally follows the other.

Again, this uniform area would be affected by the character of the form of load transference. The adoption of standard areas then would seem to be required for each form of load acceptance.

The Side Girder.

The side girder in this car differs from that of the previous form in being a continuous beam of two equal and one unequal spans, with a uniform lading upon them. The moment formulæ developed for such beams is applicable to this girder. Where the girder is cut by a door, placed over the cantilever, the condition becomes that of a simple ended beam at this point for all purposes of calculation. This is not quite true since the side sill angle is continuous and the door posts are tied at the top very securely, but such an assumption errs on the side of increased safety. The door opening arrangement through the girder may make beams of various character of end support or fastening out of the beam. This girder must be examined for deflection and of the types of beams, that of the continuous beam is least dealt with in text books in so far as deflection is concerned. To develop a formula for the deflection of such a girder it is necessary to integrate the tangent formula:

$$24EI\frac{dy}{dx} = 12M_n(2x - l_n) + 4V_n(3x^2 - l^2_n) - [W_n(4x^3 - l^3_n)]$$

This operation carried out and the constant of integration evaluated from the relations that $y = 0$ when $x = 0$ and also $x = l_n$ will give:

$$24EIy = 12M_n(x^2 - l_nx) + 4V_n(x^3 - l^2_nx) - W_n(x^4 - l^3_nx)$$

Substituting in this the value of:

$$V_n = \frac{M_{n+1} - M_n + \frac{1}{2}W_nl^2_n}{l_n}$$

and remembering that $y = \Delta$ (a maximum) when $x = \frac{1}{2}l_n$ there results:

$$\Delta = \frac{l^2_n}{16EI}(M_n + M_{n+1}) - \frac{1}{384EI}W_nl^4_n$$

This, then, is the general formula for the deflection of the central point of a uniformly loaded continuous beam.

A final investigation should show these deflections to be inappreciable. The point of greatest deflection will be found to be located at the center of the car. If the points of center-sill support for the side girder all deflect together and the deflection of the side girder is minute, the alignment of the side sills will always present the appearance of the straight line that it should.

The side girder of this form carries but the superstructure load and need not be of a similar strength for the same length as that of the first form which does all the load carrying.

It is well to note that in this type of girder the changing moments cause a greater portion of the bottom chord to be the compression member than is found in the beam with overhanging ends in the Form I. This is as it should be for load carrying, as less duty is here imposed upon the posts than in the reverse condition.

The resisting moment is the same in form as of side girder for Form I. In general it is the resistance of a plate girder considering the web plate to really perform its share of the load carrying burden.

This discussion of Form II. but supplements the general underframe remarks in the December, 1907, and the January, 1908, issues. The limitations governing weight; economy as concerns initial cost, maintenance and repair and transportation costs; reliability; and the general limitations of comfort, convenience, sanitation and æsthetics, together with the limitations imposed by special services, are there dealt with in detail. The strength and reliability factors for end shocks and vertical lading for the various services are considered and the underframe and side girder tersely discussed in general. The general theory of design for the center sills is also worked out, both graphically and analytically in those sections.

Catalogs Wanted.—Mr. T. S. Reilly, mechanical superintendent of the Yueh-Han Railway Company, Limited, Wong Sha, Canton, China, advises that he will be pleased to receive catalogs and circular matter, price and discount lists, of shop machinery, car and locomotive equipment, etc. The main line of this road, in operation at present, is about thirty-nine miles in length. Work is being rushed to get the first 250 miles constructed. At present seventeen locomotives are in service and three more have been ordered.

Canadian Railway Club Scholarship.—Mr. James Powell, secretary of the Canadian Railway Club, Box 7, St. Lambert, Quebec, announces that examinations for the four-year scholarship in applied science, at McGill University, will be held on June 15. This examination is open to minor sons of members.

GENERAL TOOL SYSTEM

ATCHISON, TOPEKA & SANTA FÉ RAILWAY.

Previous issues of this journal have called special attention to the comprehensive betterment work undertaken in the motive power department of the Santa Fé. This work was inaugurated early in 1904, at a time of labor difficulties and upon completion of one of the largest locomotive repair shops in the country, at Topeka. At the same time the managing officers undertook to make adequate provision for an immensely increasing traffic, that was clearly foreseen, by the acquisition of a large number of the most modern and very heavy locomotives for both passenger and freight service.

In undertaking the betterment work it was the desire of the management to use this motive power to the best advantage and at the same time to keep the repair costs of these large and new types of engines within a reasonable figure. Most of the locomotives were compounds, many of them of the balanced type. In order to adequately take care of the shopping of these engines, and to carry out thoroughly a system of standardization

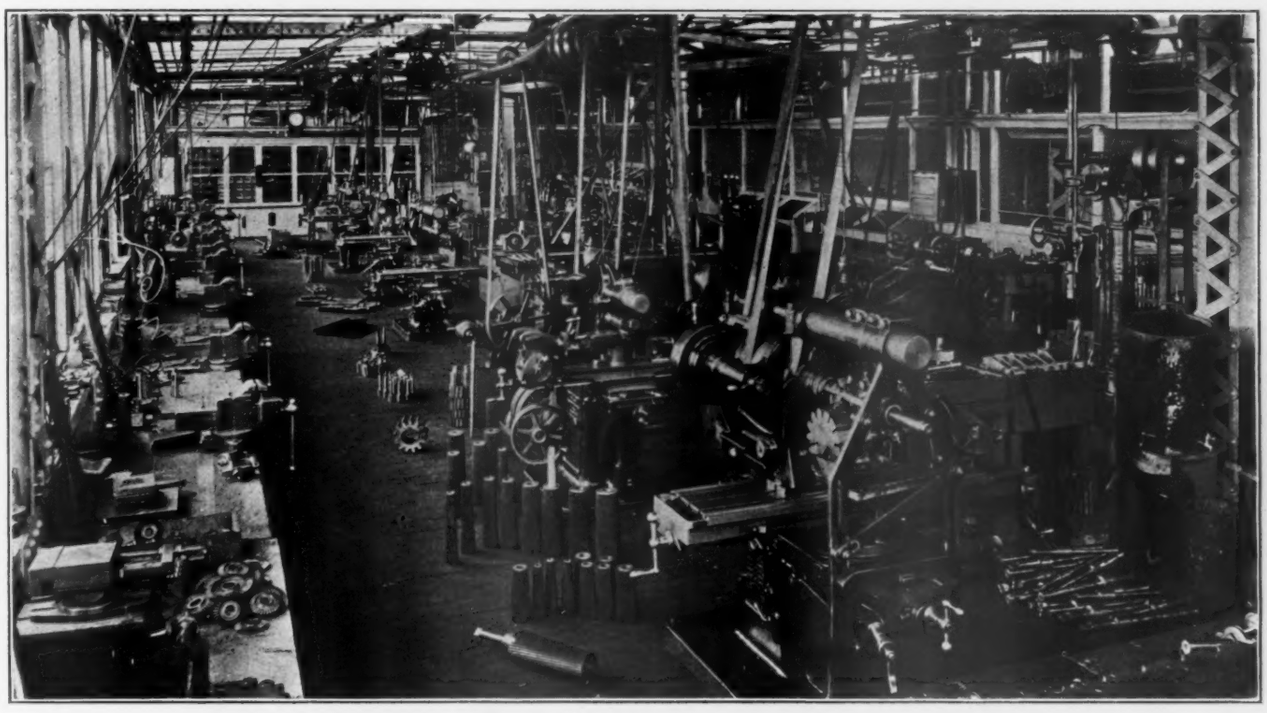


FIG. I.—MANUFACTURING TOOL ROOM FOR THE SANTA FE SYSTEM AT THE TOPEKA SHOPS.

of locomotive parts, centrally manufactured at the Topeka shops, it was realized that the tool and machinery equipments of the shops and the methods of doing the work must be the very best. For this reason special attention was directed to the tool and machinery problem at the beginning of the betterment work, an attention which has been consistently followed up to the present time.

While the technical journals have made some mention of this phase of the work, its importance as the keystone in the arch of betterment and economy for the production of efficiency has, perhaps, been lost sight of in the more extensive mention that has been made of matters of greater magnitude in the gross amount of costs involved.

The purpose of this article is to consider the details of this remarkably successful application of commercial tool methods to railway shop practice. The plan of this supervision comprised:

First. The use of tools that would foster the wholesale production of standard locomotive and car parts at the central shop.

Second. The development and application of special tools, jigs, devices and facilities that would lighten the labor of the men and increase their output capacity, thus acting as an almost inseparable adjunct to the introduction of an individual effort system of reward.

Third. The betterment of machines, including motors, shafting, pulleys, etc.

Fourth. To effect simultaneously with these results an economy in the excessive expenditures for tools of all kinds, by eliminating waste, introducing more durable and serviceable types, and avoiding undesirable investments.

Fifth. The close and detail supervision of tools, machines and methods in railroad work, as it is found by Fred W. Taylor to be, in commercial work, an indispensable factor of shop betterment and individual labor reward; it is, moreover, possible to effect many cost reductions by the methods alone, irrespective of the labor stimulus, as in the case of cylinder and eccentric drilling jigs and other jigs.

This involved the development and manufacture of many classes of tools as indicated in the following synopsis:

1.—General tools and devices for use generally over a large part of the work and in almost all shops, including:

a—Three sizes of bevel gear angle device for getting into restricted quarters with an air motor. See Fig. 2.

b—High speed flat drill chucks, No. 5 Morse taper shank. See page 458, December, 1906, issue.

c—Knuckle joint reamers.

d—Universal joints for reaming in restricted quarters.

e—Standard punches, stocks and couplings. See page 459, December, 1906, issue.

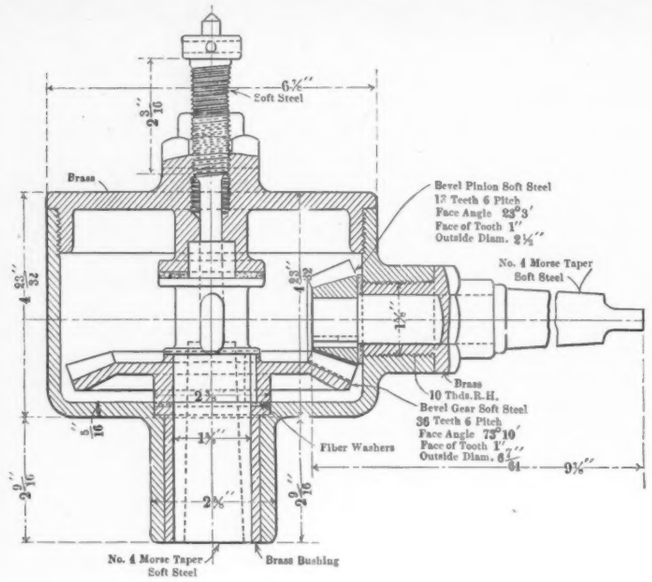
f—Standard worm driven air hoist. Fig. 3.

g—Standard blacksmith tools. Illustrated by flatter shown in Fig. 4.

h—Standard rivet snaps.

i—Standard high-speed lathe, planer and boring tools.

k—Various standard taper reamers for erecting work, such as:



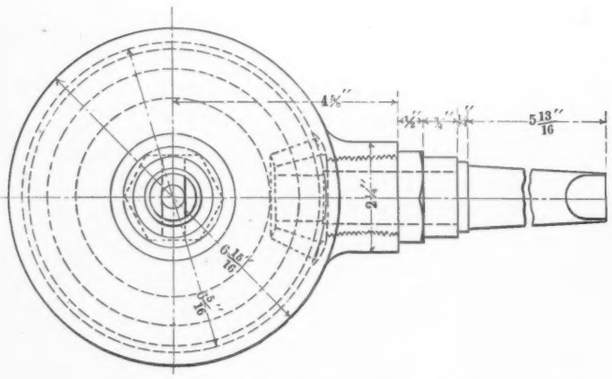


FIG. 2.—ANGLE DEVICE FOR DRILLING AND REAMING IN CLOSE QUARTERS. THREE SIZES ARE MADE, THE ILLUSTRATION SHOWING THE LARGEST.

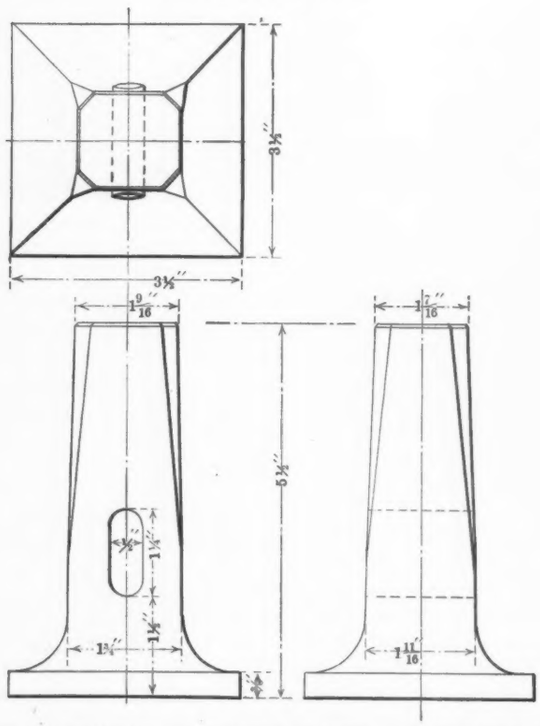


FIG. 4.—STANDARD BLACKSMITH FLATTER. AN EXAMPLE OF ECONOMICAL STEAM HAMMER FORGING.

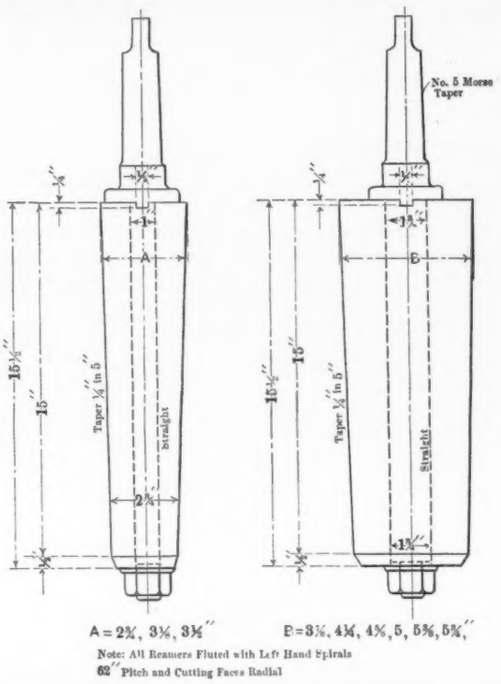

No. 5 Morse Taper
A
B
Taper ¼" in 5"
Straight
A = 2¼", 3¼", 3½"
B = 3¾, 4¼, 4¾, 5, 5⅜, 5¾"
Note: All Reamers Fluted with Left Hand Spirals
62° Pitch and Cutting Faces Radial

FIG. 5.—STANDARD CROSSHEAD AND PISTON REAMERS. THERE ARE NINE SIZES IN ALL WITH DIAMETERS VARYING BY THREE-EIGHTHS OF AN INCH. THE THREE SMALLER SIZES ARE MOUNTED ON 1-IN. ARBORS AND THE SIX LARGER SIZES ON 1¾-IN. ARBORS. ALL OTHER DIMENSIONS ARE UNIFORM.

Standard taper reamers for blade pins used on all standard classes of engines, thus making it possible to manufacture blade pins on an automatic machine.

Standard taper knuckle joint pin reamers used on all classes of engines, reducing the number of reamers in each shop to only four.

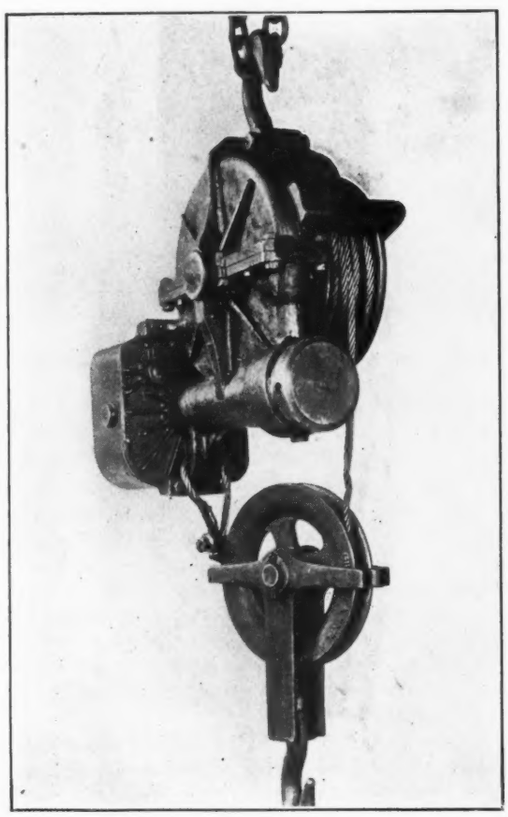


FIG. 3.—STANDARD MOTOR BLOCK AND TACKLE, DESIGNED AND BUILT IN TOPEKA TOOL ROOM. AN EXAMPLE OF CAPACITY FOR REFINED MANUFACTURE.

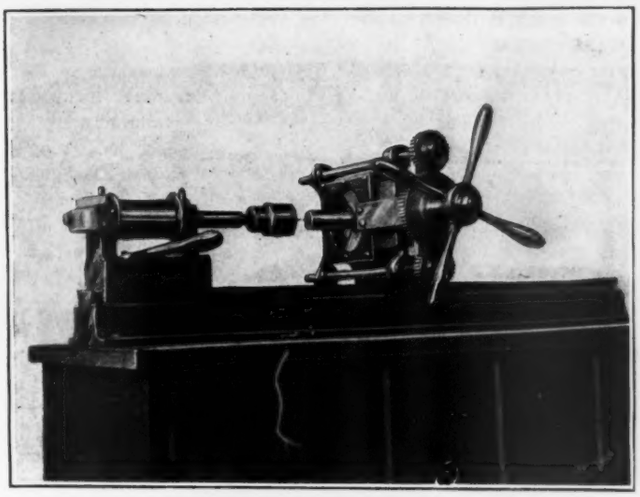


FIG. 8.—CENTERING MACHINE DESIGNED AND BUILT IN CENTRAL TOOL ROOM. THE COST OF THE MACHINE IS LOW; IT IS RAPID AND ACCURATE IN OPERATION.

the shops. (See pages 458 and 459, December, 1906, issue.)

2.—Special devices, such as mandrels and chucks, to facilitate the machining of various classes of work.

3.—Jigs—attachments to machines for the economical production of various kinds of work.

4.—Templets and jigs, such as illustrated in Fig. 7, to obviate the necessity of laying out work. Includes jigs and templets for:

a—Drilling steam chest stud holes.

b—Drilling cylinder stud holes.

c—Drilling cylinder saddles, cylinder heads, valve chamber heads, spiders, follower plates, eccentric straps, steam pipe elbows, packing glands.

d—Laying off driving box brasses.

e—Drilling flue roller casings.

5.—Special machines:

a—Centering machine, illustrated in Fig. 8.

b—Snap ring packing ring milling machine. See page 334, September, 1904, issue.

c—Crank axle pin turning machine. See "The Solution of the Crank Axle Problem," in this issue.

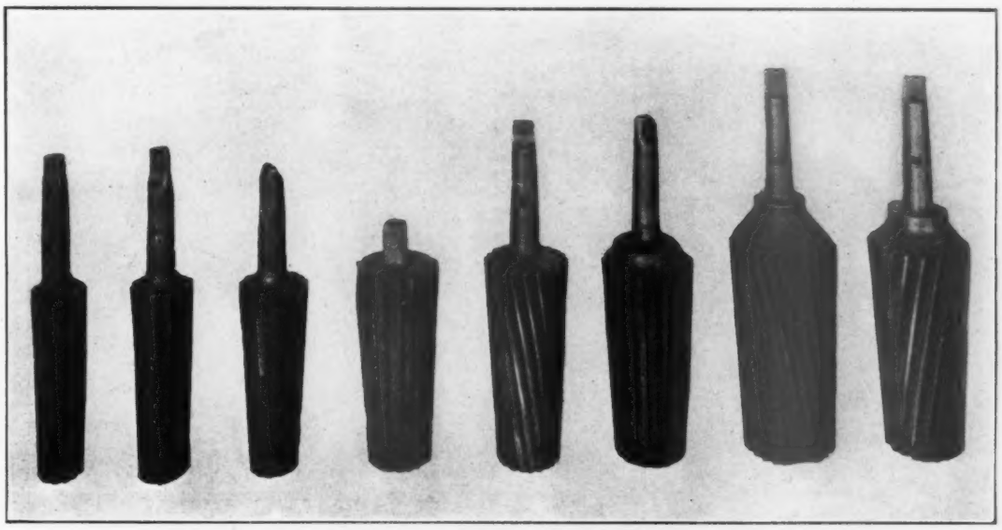


FIG. 6.—THE KIND OF REAMERS, WITHOUT STANDARDS AS TO SIZE, TAPER, LENGTH, OR MANNER OF CONSTRUCTION AND DESIGN, THAT RESULTED IN ONE SHOP FROM THE WORKING OUT OF THE IDEAS OF THE INDIVIDUAL FOREMAN. THESE REAMERS ARE THEMSELVES NOT ONLY SEVERALLY MORE EXPENSIVE TO CONSTRUCT THAN THE STANDARD ONES, AND LESS EFFICIENT IN OPERATION, BUT THEY ALSO MAKE THE WORK ON THE LOCOMOTIVES VERY COSTLY IN REPAIRS AND REPLACEMENTS.

Standard taper link motion pin reamers. Standardizing the taper on all link motion pins of all engines will not only reduce the number of reamers at each point to a minimum, but will make it possible to concentrate the manufacture of pins at a central point, supplying all outside points on requisitions.

Standard crosshead reamers. The taper on piston, crosshead, and wrist pin fits was standardized for all classes of engines on the system, reducing the number of reamers to only nine as shown in Fig. 5.

Standard reamers for reaming frame holes to standard sizes, making it possible to concentrate the manufacture of finished engine bolts for the system at Topeka, thus using the automatic bolt machine to its full capacity.

Besides these, nine special standard ball joint reamers, with inserted blades diametrically opposed but unevenly spaced, were shipped to the principal points on the system in order that a standard radius might be made on all steam pipes on engines passing through

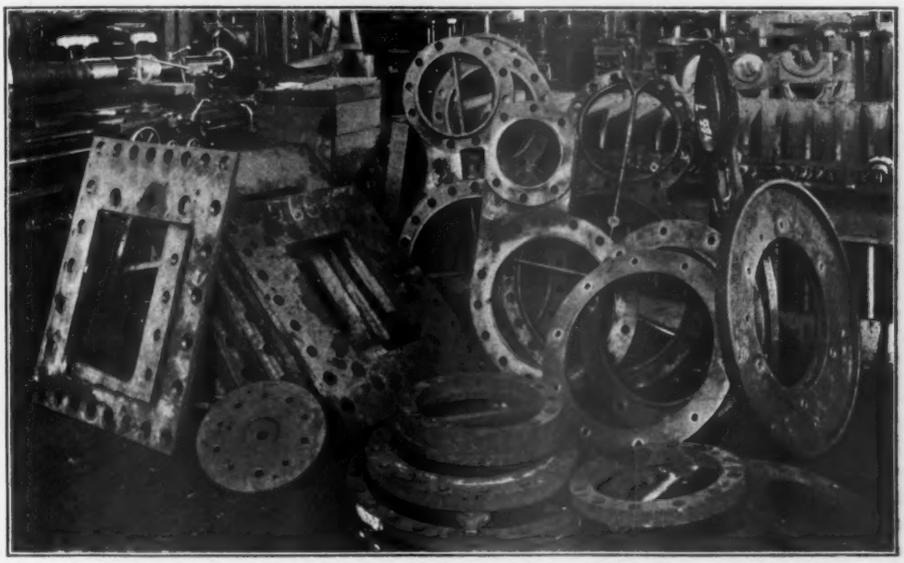


FIG. 7.—CYLINDER, CYLINDER HEAD AND STEAM CHEST JIGS FOR DRILLING STUD HOLES ACCURATELY, THUS INSURING THE USE OF STANDARD MANUFACTURED PARTS. HARDENED STEEL BUSHINGS FOR THE VARIOUS SIZES OF DRILLS ARE PROVIDED WITH THESE JIGS.

d—Complete re-construction of cylinder boring machine, as shown in Fig. 9.

6—Machine improvements:*

a—Speeding up line and countershafts.

b—Pulleys enlarged.

c—Wider driving cones applied.

d—Larger feed cones and gears.

e—Use of bronze worms.

f—Steel gears and pinions.

g—Increase in size of motors for motor drives.

h—Standard abrasive wheel stands. Fig. 10.

7.—High speed milling cutters and gang cutters:

a—For heavy production work on shoes and wedges.

b—Cutters with inserted teeth for side rod channels, eccentrics, eccentric straps, etc.

c—For small accurate work on flanging dies, MCB tire and knuckle gauges, tire finishing tools.

and the work is directly under the supervision of the general tool foreman.

The general storehouse stock of standard tools, as shown in Fig. 12, is an indication of the economy and advantage incident to the policy of centralized standard duplicate manufacture of railway tools, instead of the general practice of each local shop manufacturing individually from individual varying and special designs. Under the new policy not only are the tools more perfectly designed and built, and more cheaply, but the needs of all shops are served more promptly and efficiently by the finished stock at the general storehouse, a stock which is much smaller than would be needed, were each local shop to protect its own requirements.

The foregoing covers in a general way the mechanical features of the tool system, as carried out in successful practice. In order to make the system effective, and maintain an efficient but minimum stock of tools at all shops, a tool stock book is provided.

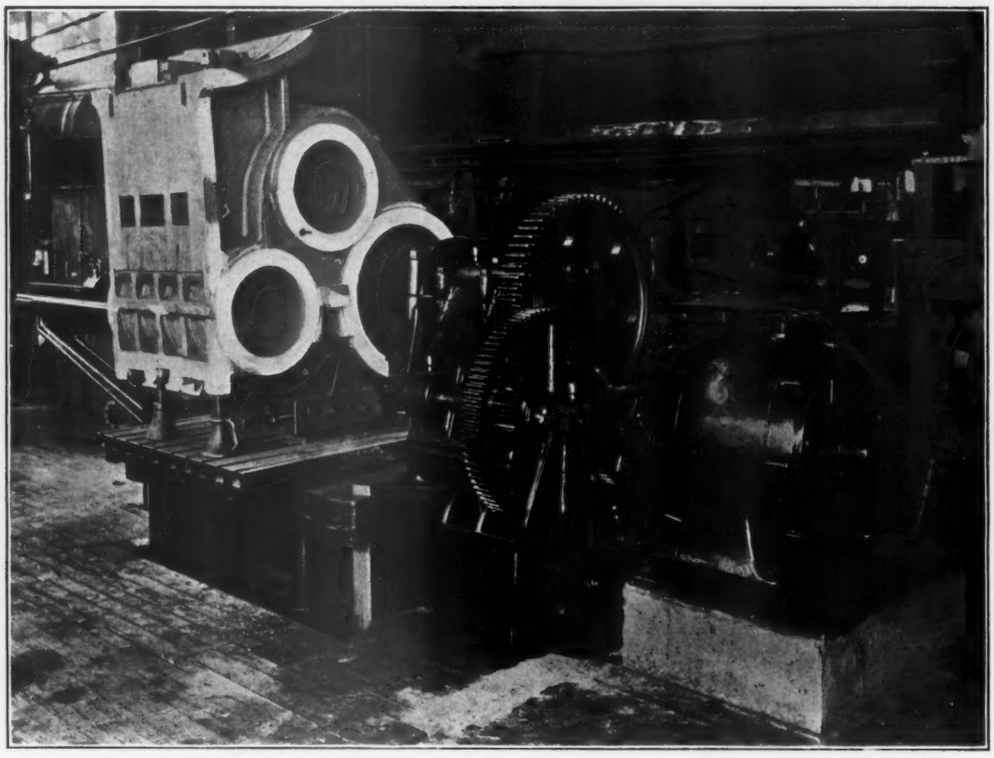


FIG. 9.—IMPROVED CYLINDER BORING MACHINE ENTIRELY RECONSTRUCTED IN RAILROAD SHOP AND TOOL ROOM. THIS IS AN EXAMPLE OF THE FACILITY WITH WHICH EVEN LARGE SPECIAL MACHINES MAY BE PRODUCED BY A THOROUGHLY ARRANGED AND EQUIPPED TOOL ROOM AND FORCE. THIS MACHINE WILL BORE, FACE AND FINISH COMPLETE AN 18-INCH SINGLE CYLINDER IN FROM TWO TO THREE HOURS, WHICH IS EQUAL TO THE PERFORMANCE OF ANY COMMERCIAL TOOL.

The general tool room at Topeka is equipped to handle tool work of every description, having all the facilities and labor-saving devices and methods that have proven really efficient. Examples of lessened costs of production under the new system, with improvd quality of output, may be given:

Turning flue roller pins, former day's output, 8 in 10 hours; present output, 46 in 10 hours.

Milling a 28½" reamer, complete, former time, 7 hours; present time, 3.2 hours.

Forging blacksmith flatter under steam hammer, former cost, 24c.; present cost, 13c.

Another new departure in railroad practice is shown in Fig. 11; this is a special tool hardening room equipped with a gas furnace and annealing ovens, water, oil and air baths, and all facilities for the production of perfect tools without failure. The temperatures for exactly uniform product are determined by an electric pyrometer, and not by color, thus eliminating all chance of error. This room is adjacent to the manufacturing tool room

* See article on "High Speed Steel in Railroad Shops," by Henry W. Jacobs, in the September, 1904, issue.

The sample page of this book, illustrated in Fig. 13, shows the arrangement of columns for keeping a record of tools on hand and on order, by months. The book is ruled so that a double page contains the record for a fiscal year, thus providing a perpetual inventory.

On the first of each month all books are sent to Topeka, along with the monthly requisition for the tools required. The books are then checked up with the requisition and immediately returned. Requisitions for tools are made once each month. A direct supervision over each tool room of the system is thus obtained and the maintenance of the tool room equipment is not left to the individual judgment of each tool room foreman. This method has not only kept down the stock of tools to a minimum but greatly increased the efficiency of every tool room on the system.

The methods, organization and details of operation of the tool system have been covered in a bulletin issued by the assistant superintendent of motive power. This bulletin is posted in all shops of the system for the instruction of both foremen and workmen. By this means all concerned are made familiar

FIG. 11.—TOOL HARDENING ROOM AT TOPEKA SHOPS. HERE ALL THE CUTTING TOOLS MANUFACTURED IN THE TOOL ROOM ARE TEMPERED OR HARDENED.

FIG. 12.—GENERAL STOREHOUSE STOCK OF STANDARD TOOLS MANUFACTURED IN TOOL ROOM AT TOPEKA AND SUBJECT TO REQUISITION FROM ALL OUTLYING SHOPS.

with the rules and regulations of the tool system, and the co-operation which naturally follows has greatly increased the efficiency of tools and tool rooms. The bulletin referred to is as follows:

TOOL REGULATIONS.

Proper and economical work depends upon the tools used, the condition in which they are kept, and their availability for service when needed. System must be used in the care and distribution of tools, so that excessive amounts of them will not be accumulated, and so that expensive tools

(Form 1077 Standard)

Santa Fe

STOCK BOOK

Section

Catalogue Page	DESCRIPTION OF ARTICLES	Symbol Number	Units of	JUNE		JULY		AUGUST		SEPTEMBER	
				Inventory	Ordered	On Hand	Ordered	On Hand	Ordered	On Hand	Ordered

FIG. 13.—UPPER PART OF ONE PAGE OF TOOL STOCK BOOK IN WHICH EACH SHOP KEEPS A RECORD OF TOOLS ON HAND AND ON ORDER. RECORDS FROM JUNE TO SEPTEMBER ARE CARRIED ON THIS PAGE AND THE REMAINING EIGHT MONTHS ON PAGE OPPOSITE.

will not be kept idle in one place when they are needed in another; system must be used in the standard design of tools and methods of doing work adopted, so that the work may be properly and economically done.

With these objects in view all decisions as to designs of tools, jigs, special devices, etc., and as to methods of doing work, will be made after reference through the office of Assistant Superintendent Motive Power, at Topeka; all suggestions as to changes in methods and all ideas as to changes in design of tools, devices, etc., or as to new forms of tools or new jigs and devices, must be submitted to that office in duplicate, and receive the approval of the Assistant Superintendent Motive Power, before they can be put into effect or be adopted. This is necessary, as often ideas and methods are developed at considerable expense in one place, when they have been already tried and proven unsatisfactory elsewhere. This useless expense should be avoided. Recommendations may be made either through the regular channels, or directly by the men.

41s11-8-08-10M-2428 (Form 2028 Standard.)

Santa Fe.

IN ALL CASES WHERE TOOLS ARE LOST, BROKEN OR DAMAGED, THIS CARD MUST BE FILLED OUT.

TOOL BREAKAGE CLEARANCE.

(ONLY ONE TOOL TO EACH CARD.)

Check Here

No. ..... has { ..... Worn Out ..... Damaged ..... Broken ..... Lost

(SHOP LETTER, NUMBER AND NAME.)

..... size .....

(GIVE FULL NAME OF TOOL.)

INITIALS HERE. DATE

as a result of { ..... Defective Material ..... Accident ..... Ignorance ..... Carelessness

..... GANG FOREMAN.

O. K. ..... TOOL KEEPER.

This card must be signed by your Foreman, one of the following: ..... GEN'L TOOL FOREMAN.

..... GEN'L FOREMAN.

FIG. 14.—TOOL BREAKAGE CLEARANCE CARD. WHEN A TOOL IS LOST OR BROKEN, A CLEARANCE CARD PROPERLY SIGNED MUST BE PRESENTED AT THE TOOL ROOM BY WORKMAN TO OBTAIN HIS CHECK ON TOOL.

A system for checking tools out from the tool room, checking them up in the tool room, and inspecting them while out of the tool room, has been developed from the best practice in use at first-class shops, and will be thoroughly installed in all tool rooms on this system.

This tool system will comprise the following features:

A. Perpetual or continuous inventory will be had of all tools, machines, and devices of all sorts at each shop, showing location of tool, whether assigned to tool room stock or to the permanent use of an individual man or gang.

B. Uniform aluminum checks of special design, six to each man, will be furnished from Topeka for each shop, indicating the shop and the block number of the mechanic to whom issued; these checks will only be issued to such men as require to call on the tool room for tools; Topeka will be called on for such checks as are required from time to time, which will be forwarded by railroad mail.

C. Standard tool lockers will be assigned to men using tools as far as practicable.

D. Standard tool kits for each class of occupation will be determined upon and these kits will be supplied to each man when he enters the service, he signing up for same and being held responsible therefor: the man will also be held responsible for the checks issued.

E. A regular weekly inspection system of all tools will be inaugurated as rapidly as it can be organized.

In addition to these general measures the following special regulations will be in force:

1. No tools will be issued from tool room except for tool check.
2. No new hand-hammers or monkey wrenches to be given in exchange for old ones unless accompanied by an order from the gang foreman and marked "OK" by shop foreman; chisels and soft hammers to be the only tools exchanged for new ones without a written order.
3. No letters or figures to be given out in lots of less than a full set.
4. All tools out on check must be turned into the tool room every Saturday night before the tool-keeper leaves the shop. In all cases where tool checks remain on the board over Sunday, the tool-keeper should notify the tool room foreman or the general

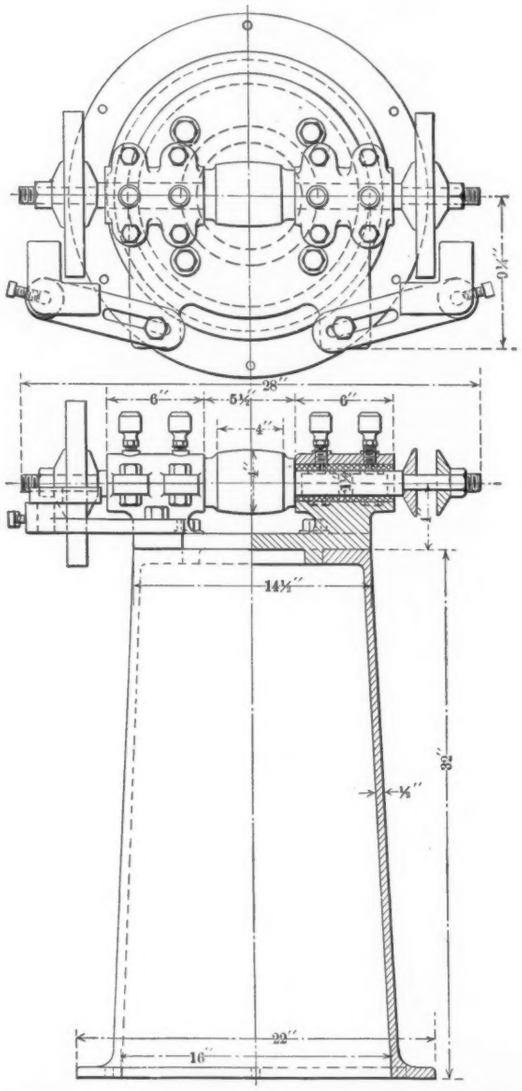


FIG. 10.—STANDARD ABRASIVE WHEEL STANDS FINISHED IN TOOL ROOM AT TOPEKA, AND IN GENERAL USE IN ALL SHOPS ON THE SYSTEM.

foreman, and the men whom these checks belong to should be required to give an explanation for not returning the tools. In some shops it may be desirable to check the tools up daily.

5. In all cases of broken, or lost, or damaged tools the tool check will not be returned until the tool clearance card (Fig. 14) has been personally signed by the general foreman as per circular letter No. 358.
6. In places where, in addition to tools, the tool room is used for a sort of shop sub-store for small engine supplies, such as cutters, small bolts, etc., the gang foreman's orders will be honored for these supplies.
7. The custody of all high speed lathe, planer, and boring mill tools should come under the tool room foreman, or the man in charge of the tool room. A man starting to work on a machine requiring these tools should be given a set and these should be charged to him. Should he break one of these tools, he will exchange it for a new one in the tool room. The tool room foreman or the tool man should get a list of the number of high speed tools, the list showing size and style now at various machines, and the workmen should sign up for them.
8. All air motors must be returned to the tool room every Saturday night and be thoroughly inspected and oiled before leaving the tool room again. At shops like Topeka, Albuquerque, San Bernardino and Cleburne, it may be desirable to assign certain motors to a gang and that this gang be allowed to use these motors during the week, turning them into the tool room on Saturday night for regular inspection. All motors should be numbered and a record kept of what gang they have been assigned to. Where parts of motors are missing, the motors should not be accepted without authority of the tool room foreman. It should be the tool room foreman's duty to see that all motors are regularly inspected and repaired and oiled as often as necessary, which, for motors in service, should be as often as once a week.

While the efficiency of tools and tool rooms is of primary importance, expenditures for expensive tools and devices are not

Form 2033 Standard.

SANTA FE.

(Insert name of Railway Company.)

REPAIRS AND RENEWALS TO SHOP MACHINERY AND TOOLS [ACCOUNT 47. (Replacing old Account 17.)] AND CHARGES TO POWER PLANTS, EXCEPT ENGINES, BOILERS AND MACHINERY CHARGEABLE TO OTHER ACCOUNTS.

At.....Shops during.....190.....

	Shops.	Renewals Large Machinery in Replacement of Old and charged to Account 47.	Repairs and Renewals to Machinery Appliances, shafting, etc., except as otherwise designated on this form	Making new Tools for use with Machines.	Repairs to Tools for use with Machines, including Dressing	Repairs and Renewals of Power Engines and Boilers in shops, etc.	Repairs and Renewals to Air Line and Air Tools.	Repairs and Renewals of Abrasive Wheels.	Repairs and Renewals of Belts	Repairs to Electrical Machinery, including Cranes.	Other than Foregoing. x	Total.
		0	1	2	3	4	5	6	7	8	9	
47-A	Machine, 11											
47-B	Erecting Shop, 12											
47-C	Boiler Shop, 13											
47-D	Blacksmith Shop 14											
47-E	Tin Shop, 15											
47-F	Brass and Air Room 16											
47-G	Tool Room 17											
47-H	Water Service, 18											
47-I	Pattern Shop, 19											
47-K	Car Machine Shop, 20											
47-L	Loco. Carpenter Shop, 21											
47-M	Wheel and Axle Shop, 22											
47-N	Power Plant, 23											
47-O	Miscellaneous, 24											
	Total.....											

This account includes repairs:
Cost of material used and labor expended in repairing tools and machinery in engine houses and at locomotive and car shops and foundries:

Column No.
- (4) Including stationary engines and boilers for furnishing power.
- (1) Scaffolding and shafting.
- (7) Belting.
- (1) Other appliances for running machinery, cranes, hoists, power and hand (except electrical), drop tables, jacks and other appliances, used in connection therewith; also in repairing furnaces, forges, hydraulic and other portable jacks.

Portable scales and sewing machines used in shops. Cost of repairing heating boilers should be charged to account 16, "Buildings, Fixtures and Grounds."

Renewals: Cost of new tools: (1, 2 and 5).

Column No.
- (10) Machinery (less salvage) used in engine houses and at locomotive and car shops and foundries.
- (4) Including stationary engines and boilers for furnishing power.
- (1) Scaffolds and shafting.
- (7) Belting.
- (1) Other appliances for running machines.
- (0) Cranes.
- (1) Hoists (power and hand).
- (0) Drop tables.
- (1) Jacks and other appliances used in connection therewith.
- (0) Furnaces and forges.
- (1) Hydraulic and other portable jacks. Portable scales and sewing machines used in shops.

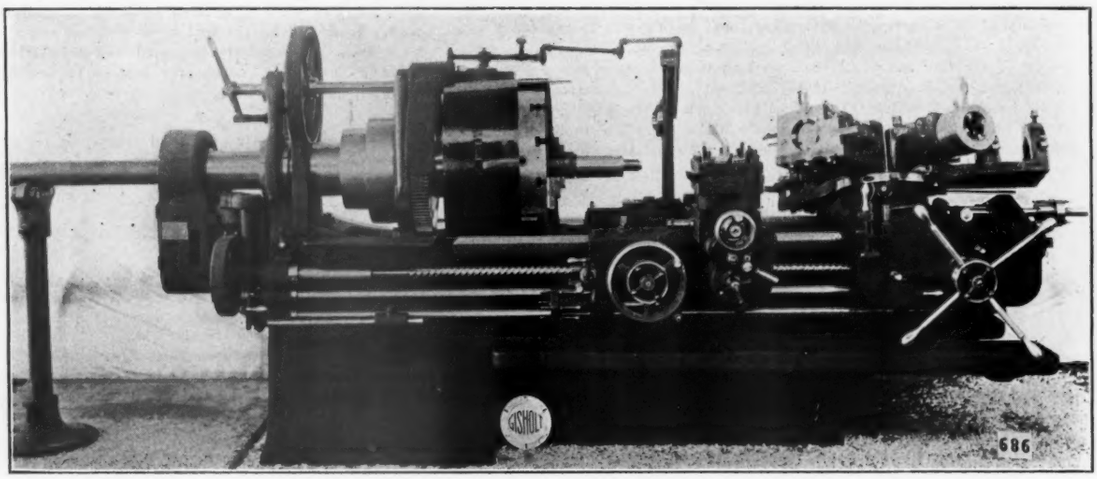
Cost of renewing heating boilers should be charged to Account 16, "Buildings, Fixtures and Grounds."

x NOTE.—Give explanation on separate sheet of each individual item constituting charges in this column.

Date..... .....Storekeeper .....Motive Power Accountant

FIG. 15.—FORM FOR KEEPING CHARGES OF REPAIRS AND RENEWALS TO SHOP MACHINERY AND TOOLS. THIS FORM IS MADE OUT AT EACH SHOP EVERY MONTH AND SHOWS THE VARIOUS CHARGES TO THE TOOL ACCOUNT.

approved unless there is a direct need for them and the saving in production costs is represented by a satisfactory return on the investment. In order to keep an accurate record of the charges to repairs and renewals to shop machinery and tools, the form shown in Fig. 15 was adopted. The form is arranged with nine columns, each reserved for a different charge account covering repairs and renewals to shop machinery and tools, and charges to power plants. This form is filled in once each month at all shops and forwarded to Topeka. An accurate check and supervision over the tool account is thus obtained and excessive expenditures for tools are eliminated without impairing the efficiency of the tool system.



GISHOLT 24-IN. LATHE WITH 5-IN. HOLE THROUGH THE SPINDLE, EQUIPPED WITH BAR TOOLS FOR MAKING CROSSHEAD PINS.

FINISHING CROSSHEAD PINS FROM BAR STOCK.

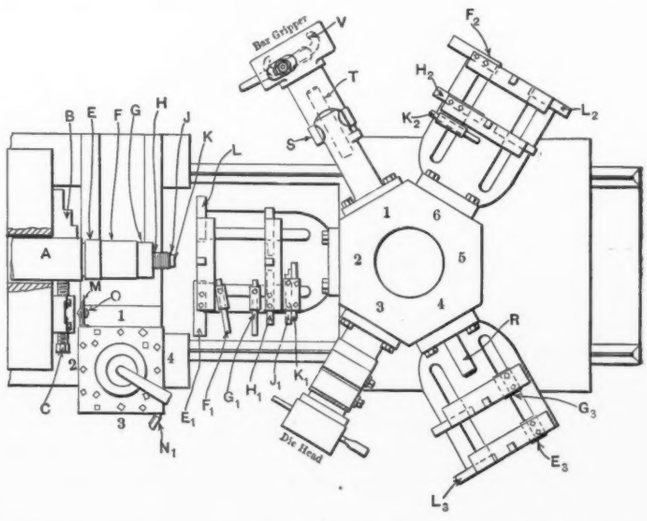
The problem of the economical production of such locomotive repair parts as are put through the shop in comparatively small lots is a troublesome one. The concentration of manufacture at central shops and the standardization of locomotive parts on the larger systems has simplified this problem to some extent, especially in the case of those parts which require frequent renewal. There are, however, many parts which even under the most favorable conditions must be put through the shop in such small lots as not to warrant the use of special machines. This condition makes desirable a machine designed for a wide range of work, which can easily and quickly be adapted to rapidly and accurately finish different parts.

The Gisholt Machine Company, Madison, Wis., started a number of years ago to develop a lathe to meet this condition. The result was a combination bar and chucking lathe; if there is not a sufficient amount of bar work to keep the machine busy it requires only a change of tools to produce chuck work. Such a machine is adapted for finishing liners, brasses, pistons, piston centers, front and back cylinder heads, piston followers, bull rings, eccentrics, eccentric straps, crossheads, pipe flanges, steam chest covers and work off the bar, such as crosshead pins, valve motion pins, brake hanger pins, etc. It has been found that in many cases these parts can be finished in lots of as few as six or eight with a saving of from 50 to 80 per cent., and upwards, over former methods.

In the case of the pins which are made from bar stock, the expense of making forgings is done away with, and, because of the manner in which the work is chucked, no time is lost in centering it in the machine. In some shops such parts as knuckle and crosshead pins are finished complete except the tapered surfaces, which are left a little large and are finished to the required size as they are needed. To give a general idea of the way in which such pins are finished from the bar the following description of the finishing of a crosshead pin on a Gisholt Big Bore lathe, with a 5-in. spindle bore, is given. The piece of bar stock, A, is held in the three-jawed scroll chuck by hard chuck jaws, B, and also by three chuck blocks, C.

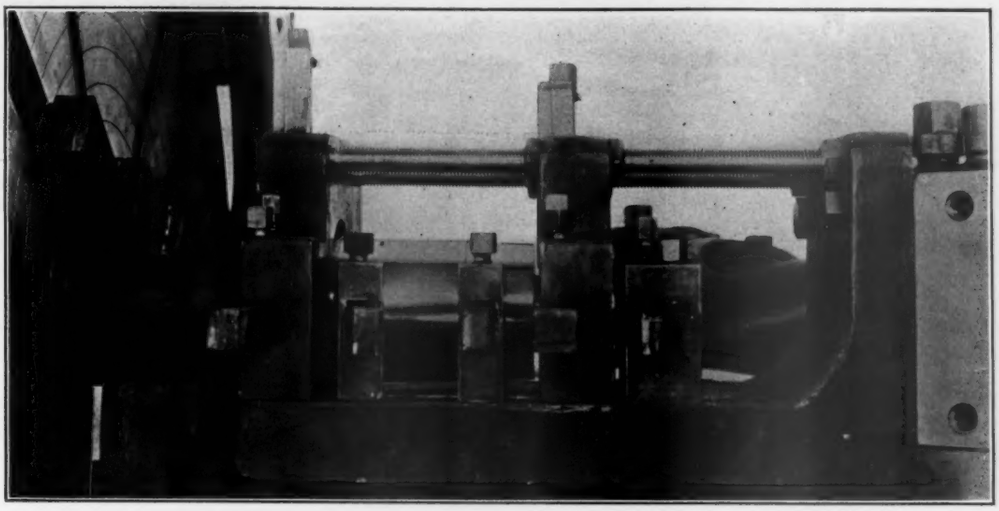
The first operation consists in removing the greater part of the surplus stock, bringing the pin approximately to size. This roughing operation is completed by the cutters shown in the box tool attached to face 2 of the main turret, the cutters E-1, F-1, G-1, H-1, J-1 and K-1 removing the stock on the surfaces indicated by the corresponding letters on the piece itself. Just before starting this roughing head the tool post tool, N, is used for truing up the end of the bar.

The next operation consists in bringing surfaces F and H to exact size. This is done with cutters F-2 and H-2 in the box tool on face 6 of the main turret. Cutter K-2 faces the end K of the piece and at the same time gauges the length of the pin; L-2 acts as a back rest for supporting the pin.



The box tool on face 4 of the main turret is then swung into position and the cutters G-3 and E-3 bring surfaces E and G to correct size and taper; the arbor R is arranged as a gauge to determine the proper location of the tapered surfaces, thus insuring duplicate work when cutters E-3 and G-3 are once properly set; L-3 is a back rest.

All surfaces on the pin having been brought to size, the next operation consists in cutting the thread, which is done with the die head on face 3 of the main turret. This completes the piece; the tool post cutting off tool M supported by post O is then used for cutting off the finished pin.



SHOWING BORE TOOL AT WORK ON CROSSHEAD PIN ON GISHOLT BIG BORE LATHE.

After the piece has been cut off the jaws and blocks are loosened and the bar gripper shown on face 1 of the main turret is swung into position. This bar gripper consists of a pair of self-acting jaws, V, for gripping the piece and drawing it out, and an arbor, T, for pushing the piece back to the proper position. The operation is as follows: Through a rapid traversing device the bar gripper is brought rapidly to the piece and the self-acting jaws, V, grip the stock firmly; then, by operating the turret rapid traversing device, the bar is drawn out to approximately the proper length. The jaws V are released and the forward half of the bar gripper is swung upwards at right angles on the hinge S, thus exposing the arbor T, which is used to push the piece back, leaving the proper length of stock projecting.

50-TON ALL-STEEL DROP-BOTTOM GONDOLA GAR.

CHICAGO, BURLINGTON & QUINCY RAILROAD.

The Chicago, Burlington & Quincy Railroad has recently received one thousand 100,000 lb. capacity all-steel drop-bottom gondola cars, which were built by the Bettendorf Axle Co., Davenport, Ia. These cars are of a light but exceedingly strong type of construction and possess several novel features of design. It is an unusually open type, as may be seen from the illustrations, making inspection easy; a large proportion of the different members are of standard rolled sections, which may be purchased upon the open market and are easily applied. Instead of stiffening the tops of the side and end sheets by riveting on angles, or other commercial sections, the tops of the sheets are rolled into tubes of 2¼ in. inside diameter. The end sheet has a heavier top roll and in addition is stiffened by heavy corrugations.

The car is carefully designed to allow the side girders and center sill to carry their respective loads and yet unify the carrying power of all of the parts, resulting in a design in which no one part is unduly stressed and abnormal sections are not required. The inside dimensions are as follows: 40 ft. long; 9 ft. 6 in. wide, and 51 in. deep. The side sheet is of ¼ in. steel with a wide sloping flange at the bottom, which does not, however, pocket any material when the car is dumped. Each side is formed by two sheets spliced at the center of the car by a side stake and a heavy splice plate. The side is stiffened by seven pressed steel stakes, each stake being riveted to the end of the cross sill for a length of 10 in., thus making a strong construction to resist side thrusts.

The end sheets are made with a deep, heavy, top roll and are flanged at the corners for connection to the side sheets. These sheets are also stiffened by a heavy star-shaped corrugation. They are of ¼ in. steel which is cold shaped during the different operations. The end sill is a 10 in. channel, the top flange of which is bent upward and is riveted to the end sheet; the web is shaped into a long, straight corrugation across the car; poling

50-TON ALL-STEEL GONDOLA CAR—CHICAGO, BURLINGTON & QUINCY RAILROAD.

BOTTOM VIEW OF BURLINGTON DROP-BOTTOM GONDOLA CAR.

pockets are pressed into the channel web. The end sill is cold shaped in one operation, the severity of the treatment given it assuring only the best grade of open hearth steel being used.

The most radical departure from other designs is that only a single center sill is used. This is designed to carry about 58 per cent. of the load when the car is loaded uniformly or to carry the entire load in case it is concentrated. The center sill is built up of four members: a 24 in., 80 lb. I-beam; an 18 in. cover plate and two Bettendorf cast steel center sill ends or draft sills. The I-beam center sill extends between the bolsters; the web is cut out at each end and the bottom flange is forced upward, reducing the depth at the ends from 24 to 15 3/16 in. The

Bettendorf center sill ends are of cast steel with draft lugs cast integral and are arranged for Miner tandem draft gear, although they may be designed to accommodate any draft gear desired. The center sill ends extend from the striking plate to back of the body bolsters where they are securely riveted to the center sill I-beam. The body bolster is continuous and passes through the center sill ends and is securely riveted to them, both top and bottom. The cover plate extends the entire length of the car. The drop door hinge butts are riveted to the cover plate and the web of the center sill. Permanent floor plates of 5/16 in. steel extend from the body bolster to the end sill, and are riveted to tom flange of the side sheets.

Five 10 in. I-beams and two Bettendorf body bolsters constitute the cross sills. Each cross sill is made strong enough to transmit its load to the center sill, and is continuous from side to side of the car. The top flange of the I-beam cross sill is pressed down at the center, thus allowing it to come flush with the floor level without making a cut in the top flange of the center sill.

The load is dumped by means of 12 drop-doors, operated by winding chains and a 2¼ in. diameter shaft. The doors are made of 5/16 in. steel, flanged and secured to the center sills by malleable iron hinges. Steel hangers, riveted to the needle-beams, catch the doors and remove the strain from the winding chains when the load is dumped. The dumping mechanism is of the creeping shaft type and is protected from injury by the bottom flange of the side sheets.

The trucks are the Bettendorf standard, cast steel, side frame, 50 ton type. The journal boxes are cast integral with the side frames, and the arch bars, columns, bolts, etc., are dispensed with. The cast steel side frame reduces the weight of trucks about 1,000 lbs. per car and eliminates nearly 200 pieces per set of trucks. The light weight of the car is 37,800 lb.; the trucks weigh 14,260 lb. The light weight is said to run to about 2,000 to 3,000 pounds lighter than the usual car of like dimensions.

The fact that there are but a few hot pressed shapes facilitates repairs at small division points. The construction of the center sill gives it power to resist high buffing strains and the method of design and distribution of stresses should enable the car to withstand the severest kind of service.

OUR NATIONAL PROBLEM.—Finally, let us remember that the conservation of our natural resources, though the gravest problem of to-day, is yet but part of another and greater problem to which this nation is not yet awake, but to which it will awake in time, and with which it must hereafter grapple if it is to live—the problem of national efficiency, the patriotic duty of insuring the safety and continuance of the nation. When the people of the United States consciously undertake to raise themselves as citizens and the nation and the States in their several spheres to the highest pitch of excellence in private, State and national life, and to do this because it is the first of all the duties of true patriotism, then and not till then the future of this nation, in quality and in time, will be assured.—*President Roosevelt, at the Governors' Conference.*

DEVELOPMENT OF THE MUFFLED POP SAFETY VALVE.

The muffled pop safety valve for locomotives has, like other perfected locomotive appliances, reached its present state of excellence through a long period of development and improvement. The history of this type of valve dates back over twenty years, previous to which time it was not considered possible to muffle the sound from an escaping pop valve.

The first muffler applied by the American Steam Gauge & Valve Mfg. Co., who were among the pioneers in introducing

this improvement, is shown in Fig. 1. It consisted of an extra attachment which could be applied to any safety valve and included a brass casing completely enclosing the valve and open at the top. The outlet for the steam was obstructed by two mufflers, each consisting of three concentric rings of coiled wire held between a couple of perforated plates. These two layers were placd a short distance apart, so that the complete effect of each could be obtained.

The muffled pop valve soon became very popular and Fig. 2 shows a combined pop valve and muffler which was built by the same company about 1896. As can be seen from the illustration, the muffling section follows the early plan of having rings of coiled wire held between perforated plates through which the outgoing steam must pass. In this case, however, there is but one section. The valve itself is a considerable improvement over the earlier pop valves and includes a regulating ring which can be adjusted from the top of the valve by removing the muffler casing. The compression of the spring is also adjustable from the same point. It will be noticed that it was not considered necessary at that time to enclose the spring and it is exposed to the full passage of the outgoing steam. The wings on the bottom of the valve itself are depended upon to keep it central and the valve seat is very light compared to the present valves.

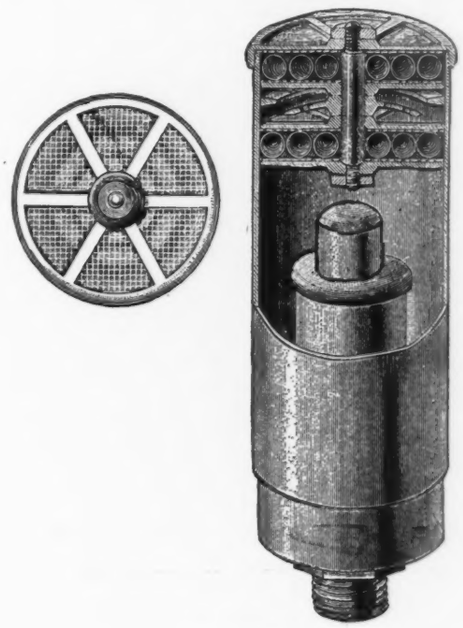


FIG. 1—1887.

This design was followed a few years later by the one shown in Fig. 3, which illustrates a big step in the development. In this valve we find the spring entirely enclosed, the valve equipped with guides both above and below, the size of the valve seat increased, and an entirely new system of muffling introduced. The same arrangement of regulating ring, which is adjustable for the top of the valve, that was used on the earlier design, has been retained. The mufflers instead of being at the top have been placed at the sides and are of an entirely new design, consisting of a large number of concentric brass rings arranged in three sections, one above the other. A full adjustment of any part of the valve can be made by removing a small top cap. This valve represents the starting point of all the later muffled pop valves of this company.

The next step is shown in Fig. 4 and consists principally of minor improvements over the previous valve. This was brought out about 1901. In it the spring has been made longer, an extra set of muffling rings has been introduced, the regulating ring has been made broader and stiffer and the spring is copper plated. In other respects, however, it differs only in heavier construction, giving increased strength and durability.

The next step in improvement of pop valves by this company is shown in Fig. 5, which illustrates a design of 3½ in. valve

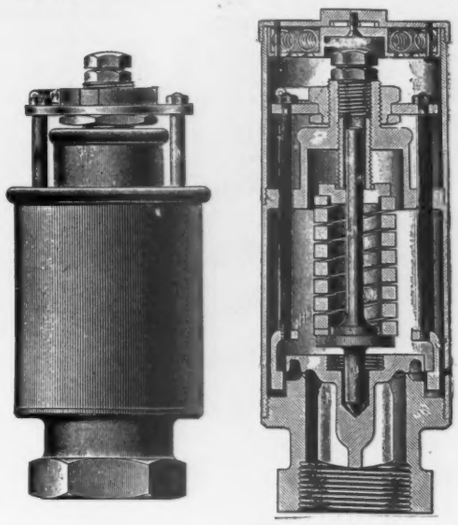


FIG. 2—1896.

brought out last year. This valve is almost as large an improvement over its immediate predecessor as was No. 3 over its predecessor. The most noticeable feature is probably the binding of the muffling rings together with phosphor bronze bolts and holding the series in place with a ring threaded on the spring casing which, after being tightened, is locked into place. The regulating ring has been greatly strengthened by being made broader and thicker and the same advantageous method of adjusting from the top of the valve which was used from the beginning has been retained. A new method of arranging the guide above the valve has been introduced, which removes all possibility of any back pressure coming on to the top of the valve. It consists of a separate guide or ring secured to the spring casing and extending outward and downward around the outer edge of the valve. This in connection with an increased length of wings below the valve removes all possibility of the valve cocking on its seat. The binding of the muffling rings together by bolts, which, as can be seen in the illustration, is done by increasing the depth of the supporting rib so that it rests on top of the lower ring, greatly reduces the vibration effect on the whole valve which in the earlier designs tended to gradually loosen all of the parts. The use of a phosphor bronze bolt permits the rings to be drawn up so securely that there is practically no chance of them becoming loosened. The two bolts carrying the regulating ring are also made of phosphor bronze. The remainder of the valve is made of the highest grade brass,

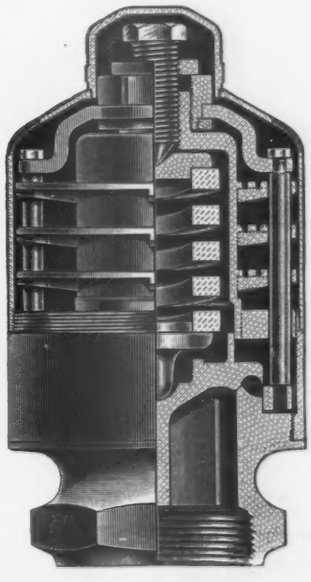


FIG. 3—1899.

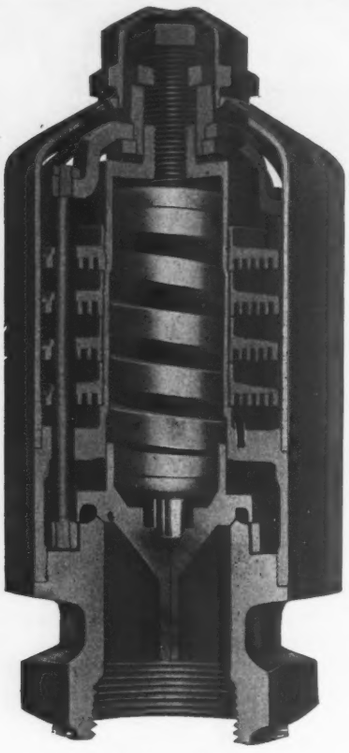


FIG. 4—1901.

the valve seat being very liberal in area and of very hard material. The spring is copper plated as in the previous valve. The adjustment of all parts is concentrated at the upper point, which is covered by a small cap. The removal of this permits the setting of the valve and the adjustment of the regulating ring.

The latest design of muffled pop valve, which has been perfected by this company during the last few months, is shown in Fig. 6. It will be noticed that some radical changes have been made, particularly in the muffling device, which instead of being a separate series of rings is, in this case, an inclined series of narrow rings, forming part of the inner casing. This change has been made with the idea of giving a freer discharge, thus reducing the back pressure in the valve chamber, and also entirely eliminating any possibility of these rings becoming loosened. The upper guide, for the valve proper, has been improved over the former design by also making it a part of the inner casting instead of a separate section.

The style of the huddling chamber and the form of relief have been entirely changed, the latter now consisting of a series of holes which terminate in a groove, the arrangement of which is shown in the illustration. The regulating ring operates by restricting the discharge through this groove instead of at the edge of the valve proper, as has previously been the case. The regulating ring itself has also been altered, being made heavier

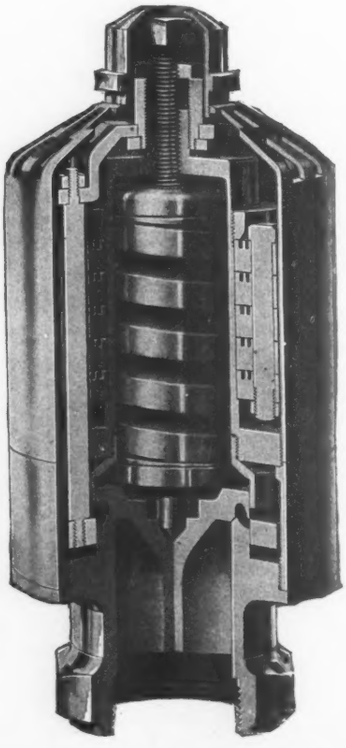


FIG. 5—1907.

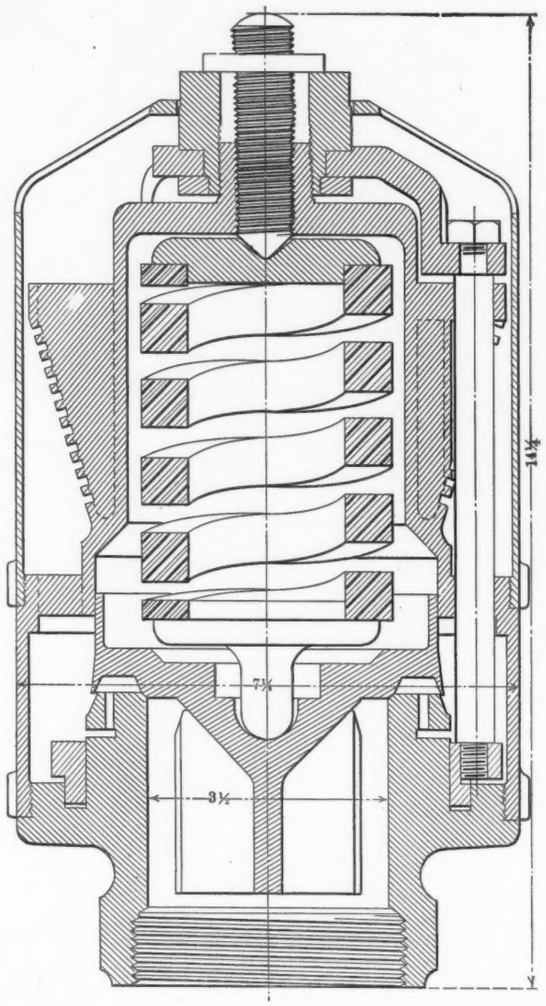


FIG. 6—1908.

and arranged with a bearing in the valve base, which, in addition to the provision for three supporting rods instead of two, will insure an even lift and prevent any possible chance of vibration.

The cap inclosing the top of the valve has been eliminated in this design and adjustment for the popping point and closing point can be made directly from the top of the valve without removing or opening any part.

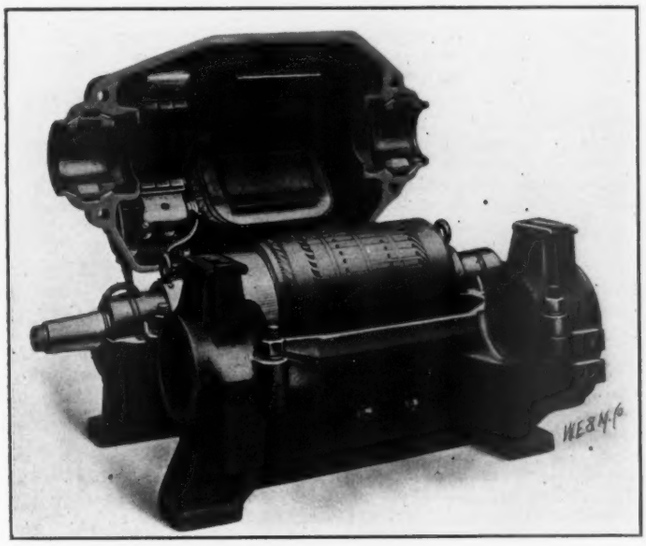
LOSS OF FUEL ON LOCOMOTIVES.—Approximately 20 per cent. of the coal supplied locomotives is used in starting fires, in keeping the machine hot while standing on side tracks, or is left in the firebox at the end of the run. Sixteen million tons of the annual consumption are thus accounted for. From 8 to 10 per cent. of the remainder is discharged as unconsumed fuel from the stack during the operation of the locomotive and the remainder is required for the generation of steam.—*Dr. W. F. M. Goss before the Amer. Soc. Mech. Engrs.*

MOTOR FOR DRIVING TRANSFER TABLES AND BENDING ROLLS.

The "mill type" direct current motor which has recently been placed on the market by the Westinghouse Company is adapted to certain classes of railroad work, such as operating transfer tables and driving bending rolls in the boiler shop. It has been carefully designed to meet the severe conditions in steel mills, and has given very satisfactory results in that service.

When used on a transfer table it may be provided with two friction clutches, one operating the drum for pulling cars or dead engines on or off the table, the other operating the driving mechanism of the table. As it is possible to disconnect both clutches at the same time, there may be times when there is no load on the motor, and an ordinary series motor would run at a speed sufficient to cause damage to itself. This motor, however, has a shunt field connection, which limits the no load speed to approximately double the full load speed.

The illustration shows the motor opened for removal of the armature. The motor frame is divided horizontally and is hinged, allowing the upper half to be quickly swung back for repairs. The heavy section of the frame insures freedom from vibration. The frame is provided with handholes for inspection of the commutator and windings, but the covers fit tightly and the frame is dustproof. The bearing housing is extended beyond the bearing and a dustproof construction is secured by means of a steel washer and felt lining.



"MILL TYPE" DIRECT CURRENT MOTOR.

The dimensions of the shaft are exceptionally large, with keyways of liberal dimensions, and all chance of bending and breaking is eliminated. A noticeable feature of the bearings is their large wearing surface, insuring long life. The air gap between the fields and the armature is large, and allows considerable wear in the bearings before the revolving and stationary parts can come in contact. Special provision has been made for preventing oil from being drawn into the armature or creeping along the shaft. The bearings are split and made interchangeable for either end of the motor. No dowel pins are used, as lugs cast on the bearings keep them from turning. An eye bolt on each bearing permits ready handling of the armature.

The insulation used on the motors is incombustible throughout, and withstands very high operating temperature without deterioration. The coils are treated with the insulating compound and then baked at a temperature far higher than any that will ever be met in actual service. The carbon holder is of substantial design, and so constructed that by the removal of one holding bolt the entire holder, as one piece, can be removed from the motor. The insulation is thoroughly protected from moisture and mechanical injury.

The armatures are wound with strap copper insulated with mica tape, handwound. This form of coil can be easily repaired, which is not possible with wire wound coils, which are useless if the insulation becomes badly damaged. The coils are held in place by hard fibre wedges and bands which are below the surface of the laminations.

A CORRECTION.—Through an error the Bridgeford 42-inch geared head engine lathe, described on page 191 of the May issue, was mentioned as a Bridgeport lathe. These machines are made by the Bridgeford Machine Tool Works, Rochester, N. Y.

PERSONALS.

N. L. Smitham, master mechanic of the Texas Midland R. R., has resigned.

A. C. Miller has been appointed to succeed N. L. Smitham as master mechanic of the Texas Midland R. R.

C. A Deweese, master mechanic of the Denver & Rio Grande Ry. at Helper, Utah, has resigned.

H. C. Eich, master mechanic of the Illinois Central R. R. at East St. Louis, has been transferred to Paducah, Ky., succeeding J. H. Nash.

J. H. Nash, master mechanic of the Illinois Central R. R., has been transferred from Paducah, Ky., to Waterloo, Ia., succeeding R. W. Bell, promoted.

A. Williamson, mechanical inspector, and F. J. Lass, mechanical engineer, of the Mexican Central Ry. at Aguascalientes, Mex., have exchanged positions.

W. C. Whittaker, formerly of Burnham, near Denver, Colo., has been transferred to Helper, Utah, as master mechanic, succeeding C. A. Deweese, resigned.

J. G. Neuffer, assistant superintendent of machinery of the Illinois Central R. R., has been appointed superintendent of machinery, succeeding Mr. Renshaw, resigned.

R. W. Bell, master mechanic of the Illinois Central R. R. at Waterloo, Iowa, has been appointed assistant superintendent of machinery, with office at Chicago, succeeding J. G. Neuffer, promoted.

A. S. Barrows, chief motive power clerk of the Chicago, Rock Island & Pacific Ry., has resigned to accept a similar position with the Delaware, Lackawanna & Western R. R., with office at Scranton, Pa.

W. Cockfield, locomotive superintendent of the Mexican Railway, at Orizaba, Ver., has resigned to accept the position of chief locomotive superintendent of the Peruvian Corporation, with headquarters at Lima, Peru.

H. O. Keay has been elected head of the department of railways at McGill University, Montreal, to succeed Clarence Morgan, who has resigned to re-enter active railroad work. The railway department, which was organized a year or two ago, has become firmly established and organized.

Orlando Stewart, formerly superintendent of motive power of the Bangor & Aroostook Ry., died at his home in Brighton, Mass., on the 27th of April, aged 74 years. Mr. Stewart retired from railroad work last fall and has been in failing health for some time. He is mourned by a wide circle of friends and his death removes a veteran railroader from the ranks.

J. R. Thompson has been appointed mechanical engineer of the Chicago Great Western Ry., with headquarters at Oelwein, Ia. Mr Thompson was formerly mechanical engineer of the Fitz Hugh, Luther Co. at Hammond, Ind.

William Renshaw, superintendent of machinery of the Illinois Central R. R., has resigned from the service of the company. Mr. Renshaw entered the service of the Illinois Central in the drafting department in 1865. From 1869 to 1882 he filled the positions of machinist apprentice, journeyman machinist, engine house foreman and general foreman. In 1882 he was appointed master mechanic of the Chicago division and later assistant superintendent of machinery, which latter position he occupied until 1893, when he was appointed superintendent of machinery.

Walter Gilman Berg, chief engineer of the Lehigh Valley R. R., president of the American Railway Engineering and Maintenance of Way Association and past president of the Association of Railway Superintendents of Bridges and Buildings, died very suddenly on May 12 from an acute attack of indigestion. Mr. Berg has been known as one of the foremost railroad engineers in the country and was a man of fine education and large experience. He was the author of a number of valuable books, among which the best known is "Buildings and Structures of American Railways," a standard work on this subject. He was also the author of "Railway Shop Systems."

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

SOUVENIR BOOK OF CARS.—The Barney & Smith Car Company, Dayton, O., is issuing a limited edition of a very attractive souvenir book entitled "Cars We Have Built." The book is given up entirely to full page illustrations of the exterior and interior of all classes of passenger cars, including sleeping, buffet and dining cars. Views of both box and gondola cars, the latter of composite or all steel construction, are also included. The book forms an excellent collection of views showing the very attractive and artistic interior of modern passenger equipment.

ELECTRICAL APPARATUS.—Among the recent bulletins issued by the General Electric Company might be mentioned No. 4582, which describes the G. E. 205 railway motor. This motor is similar in design and construction to other standard G. E. motors but is provided with commutating poles located between the main field poles. This type of motor is especially adapted for use with high operating voltage and hence, for operation on heavy grades, or with equipments intended for high speed work, which have to start and stop frequently, it is unusually well fitted. Bulletin No. 4585 is on the subject of the QC motor, which is made in sizes up to 20 h. p. and for voltages of 115, 230 and 550 direct current. This motor is especially adapted for application to machine tools.

VERTICAL SELF-OILING ENGINES.—The American Blower Company, Detroit, Michigan, is issuing catalog No. 232, superseding No. 206, which is given up entirely to the illustrating and describing of vertical self-oiling steam engines. These engines are of the small high speed type and they often run for five months on a stretch without any other attention than filling the cylinder lubricator and after that time they simply need a renewal of the interior supply of oil. They are most completely illustrated and described in the catalog, every small detail being carefully considered. They are made in practically all sizes, either with a single or double cylinder, up to 65 h. p. and will operate in some sizes as high as 800 r. p. m. The catalog includes tables showing the remarkable economy which has been attained and gives details of prices, weights and sizes.

NOTES

KENNICOTT WATER SOFTENER CO.—W. R. Toppan has resigned the position of general manager of this company.

GOULD COUPLER COMPANY.—Mr. F. P. Huntley, vice-president and general manager of the above company, has just returned from a trip of some few months abroad, where he has been on business and pleasure.

S. F. BOWSER & COMPANY.—Among the guests who lost their lives in the recent burning of the Aveline Hotel in Fort Wayne, Ind., was Mr. William A. Pitcher, who held the position of eastern railway representative of S. F. Bowser & Company. Mr. Pitcher was forty-eight years of age.

GOLDSCHMIDT THERMIT CO.—This company annonuces the establishhment of an office and works at 103 Richmond Street West, Toronto, Canada. This office is under the management of Mr. E. C. Rutherford, a Canadian by birth and a man of wide acquaintance in the Dominion.

TURBINE ACTIVITIES IN THE FAR EAST.—Included in a recent shipment from the Westinghouse plant at East Pittsburg there were not less than ten turbo-electric generators, aggregating 25,000 h. p., which are for service in the Far East, most of the machines going to Japan.

CASSIER'S MAGAZINE MOVES.—The Cassier Magazine Company announces the removal of its New York offices from 3 W. 29th streeet to 12 W. 31st street. The new address is located in an office building which has just been erected on the site of the former house of the American Society of Mechanical Engineers.

CROCKER WHEELER COMPANY.—Herbert C. Petty was on May 13th elected a director of the Crocker Wheeler Company of Ampere, N. J. Mr. Petty entered the service of this company in 1903, in the sales division, from which he was advanced to the position of contract manager, which position he held up to the present time.

WALTER B. SNOW.—Mr. Snow, who opened an office as publicity engineer some time ago, has recently increased his facilities by removal to larger quarters at 170 Summer street, Boston, Mass. He has also established an addressing and mailing department in connection with which select mailing lists will be maintained for the special use of his clients.

MECHANICAL STOKERS.—One of the largest orders ever placed for mechanical stoking equipment was received by the Westinghouse Machine Company just at the close of the year 1907. This order aggregated 14,400 boiler h. p. and was made up of 24 stokers to be used in one of the large Brooklyn power stations operated by the Transit Development Company of New York.

FAIRBANKS, MORSE & CO.—The general offices and sales department of this company, formerly at the corner of Franklin and Monroe streets, moved during the month of April, and are now located in their new building with offices at the corner of Wabash avenue and Eldredge place, Chicago. This is the home office of the company. The new office building is a seven-story structure, with basement.

LOCOMOTIVES ORDERED.—Among the recent orders received by the American Locomotive Company was a six-wheel switching engine for the Saint Louis National Stock Yards; a consolidation locomotive for the Fajardo Sugar Company and two Mallet type locomotives for the Eastern Railway of France. Orders were also received from the Paris-Orleans Railway for one 10 ft. 7 in. cut, scoop wheel type, standard gauge, rotary snow plow.

AMERICAN BLOWER CO.—The above company announces that it has purchased the foundry formerly operated by the Northwestern Foundry & Supply Company of Detroit, Mich. This foundry will be used for the manufacture of blower, exhaust fan, engine and heater castings. It announces that all of the soil pipe and fittings patterns, the complete foundry equipment and also a large stock of finished pipe fittings, etc., which were purchased with the foundry, are for sale.

CONSULTING ENGINEER.—Mr. J. Fremont Murphy, who for a number of years has been connected with the Cooke Works of the American Locomotive Company as engineer and superintendent, has opened an office in New York as a consulting engineer. He will make a specialty of railroad equipment and is available for consultations, investigations, appraisements, expert testimony, inspection, perfection of inventions and the making of tests. His office address is 1824 Hudson Terminal-Cortlandt Building.

CANADIAN CROCKER WHEELER CO., LTD.—A new company, having the above name, has recently been organized for the manufacture and sale in Canada of the well known Crocker Wheeler apparatus. Mr. F. E. Lovell, a member of a very long established lumbering firm in the province of Quebec, has been elected president of the company. Messrs. Russell A. Stinson and F. Jno. Bell, vice-president and secretary-treasurer respectively, have also long been identified with the manufacturing, construction and sale of the electrical apparatus in Canada. The head office of the new company has been opened in the Street Railway Chambers, Place d'Armes Hill, Montreal.

THE AMERICAN NUT AND BOLT FASTENER COMPANY.—This company has moved into its new plant at Ontario and Sterling streets, North Side, Pittsburgh, Pa. The company owns an entire city block and the buildings have been placed to the best possible advantage. The plant is convenient to a railroad and has connecting switches. The main building is 80 by 215 ft. and is equipped with new and the most improved machinery for manufacturing the Bartley fasteners. All of the machinery is driven by electric power. The latest improvements in the way of toilet and wash rooms are provided for the comfort of the employees. The plant has a capacity for 60,000,000 Bartley fasteners per annum; these fasteners are made in over seven hundred different styles. Bartley fasteners are sold to nearly all the railroads and car companies in the United States and to a large foreign trade. Fourteen million of these fasteners were sold during the year 1907. The company is represented in the East by Robert Spencer & Co., 20 Vesey street, New York, and in the west by Christopher Murphy & Co., 164 Dearborn street, Chicago. The main office address of the company is Post Office Box 996, Pittsburgh, Pa.

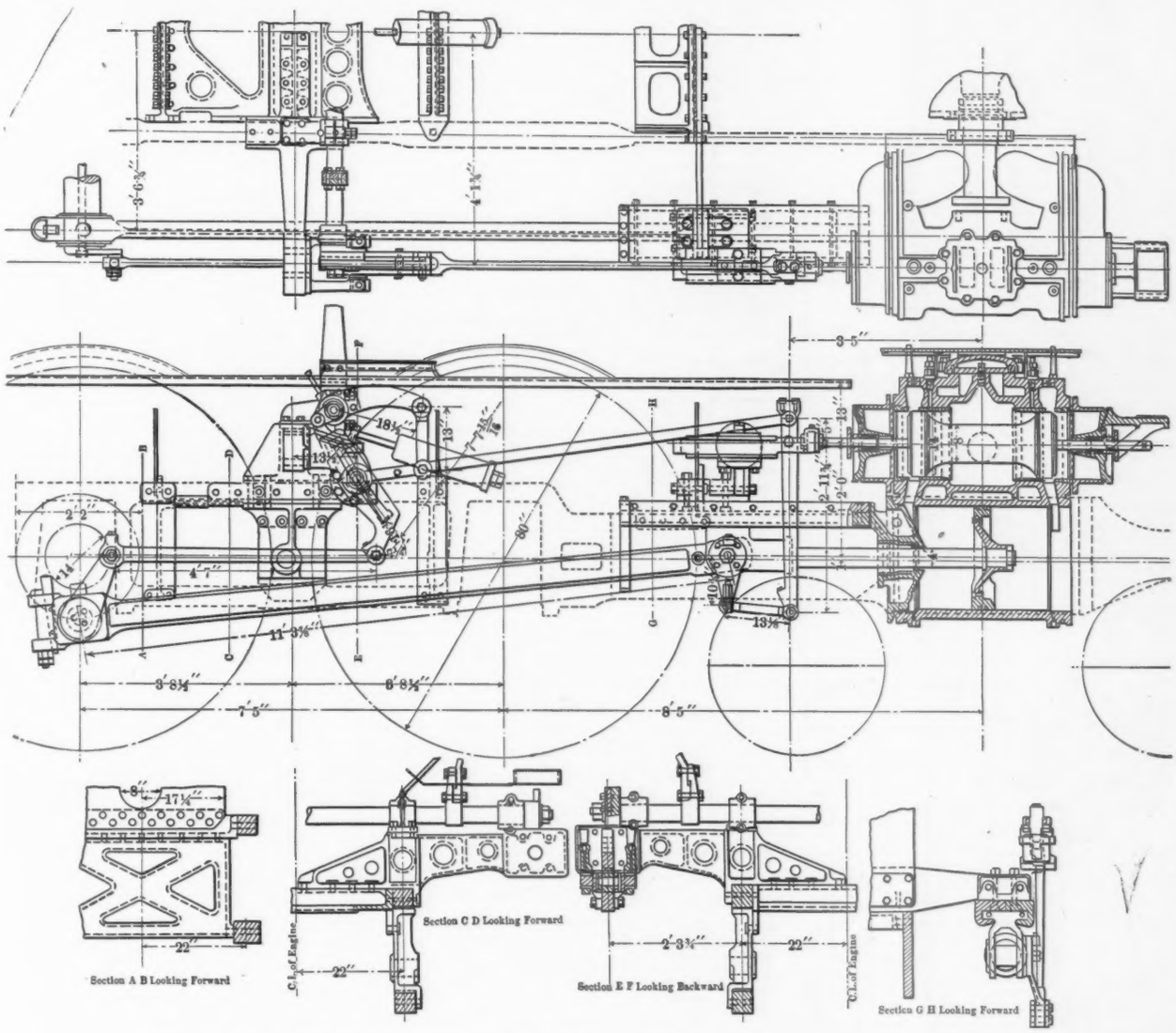
WALSCHAERT VALVE GEAR.*

PENNSYLVANIA RAILROAD.

The design of valve gear which has been developed on the Pennsylvania Railroad for use on high speed Atlantic type locomotives presents many features of refinement of detail and attention to the underlying principles of a gear of the Walschaert type which are not always found in the gears being applied. It consists of as few parts as can be used to advantage and still obtain a satisfactory motion. All moving parts are made as light as stiffness would allow and particular attention has been given to providing case hardened bushings and pins at all wearing points. Full advantage has also been taken of the opportunity presented by the use of this type of gear in obtaining an exceptionally good system of frame bracing.

The general assembled drawing of the gear shows the supports for the different parts very clearly, and a study of that drawing will show that the great importance of an absolutely rigid support for the link has been fully appreciated. Since this section of the gear must be located back of the front driver and with the center of its trunnions some distance ahead of the point midway between the drivers, it is necessary to support it from a cantilever extending out a distance of over 2 ft. from the main frames. As the link is hung 13½ in. ahead of this extending arm, a twisting action is introduced which must be opposed by a liberal length of bearing on the frame.

The construction at this point consists of a steel casting which is cored at all available points to make it as light as possible and still retain the requisite stiffness. This casting extends inward to the center line of the engine, being securely bolted to a large horizontal frame stiffening casting located at this point. It has a bearing nearly 2 ft. long on the frame with a deep lip extending down on the outside and is secured to the frame by four vertical and four horizontal bolts. At the outer end is carried a steel casting which includes the bearing for the link trunnions. A bearing for the end of the reverse shaft is also provided in this casting, the construction and arrangement of which is clearly

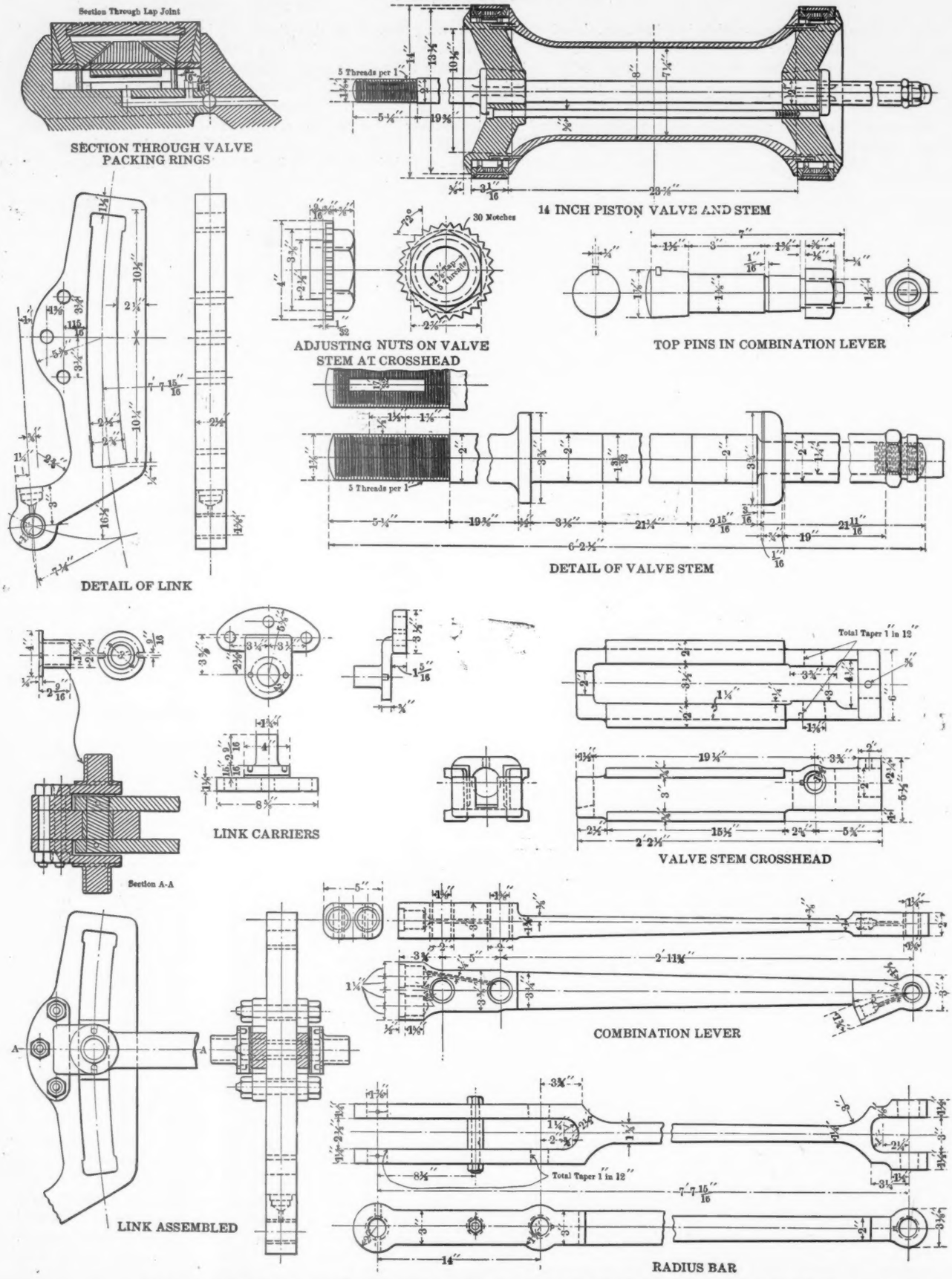


PLAN AND ELEVATIONS OF ASSEMBLED VALVE GEAR OF THE WALSCHAERT TYPE—PENNSYLVANIA RAILROAD.

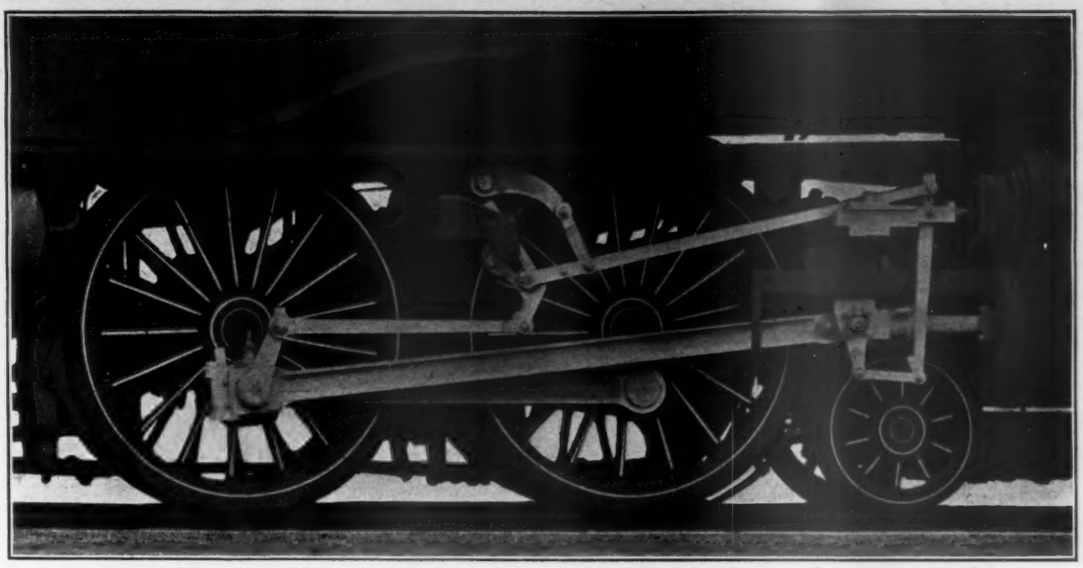
* This is the fourth article of a series describing in detail typical arrangements of the Walschaert valve gear. The standard arrangement used on consolidation locomotives on the Canadian Pacific Railway was described on page 16 of the January, 1908, issue. A typical application made by the American Locomotive Company to some Pacific type locomotives for the Florida East Coast Railway was described on page 89 of the March, 1908, issue. Details of the Walschaert gear used on a recent order of Pacific type locomotives furnished to the A. T. & S. F. Ry. by the Baldwin Locomotive Works were described on page 114 of the March, 1908, issue.

shown in the assembled drawing. The reverse shaft, which extends across the engine, is provided with another bearing just above the frame, this being in a separate casting bolted to the top of the cantilever.

The frame stiffening pieces at this point, which consist of vertical steel castings located just ahead of the rear pedestal and behind the front pedestal, and two large horizontal steel castings, being designed to give great stiffness without excessive



DETAILS OF VALVES AND WALSCHAERT VALVE GEAR FOR CLASS E LOCOMOTIVES—PENNSYLVANIA RAILROAD.



VIEW OF WALSCHAERT VALVE GEAR AS APPLIED TO CLASS E3D LOCOMOTIVE—PENNSYLVANIA RAILROAD.

weight, are worthy of attention. Another horizontal frame stiffening casting will also be noticed just back of the guide yoke, where the frame narrows down to a 2½ in. plate.

The support of the forward part of the gear is provided by the valve stem cross head which has very liberal bearing area and is carried in guides supported from the top of the main guide just ahead of the yoke. It will be noticed that an extension valve stem with a stuffing box and bearing in the front valve chamber head is used, which will assist in keeping this section of the gear in line and relieve the cross head to some extent.

The illustrations of the details of the gear show its refinement and extreme lightness combined with sufficient rigidity to prevent it from springing or otherwise getting out of adjustment at very high speeds. The whole gear, from the center of the pin on the return crank to the center of the valve stem, is all in one vertical plane, so that no horizontal lever arms are introduced at any point. Provision has been made throughout for the convenient and easy removal of any part which may need attention, without dismantling other sections. The return crank is held to the main pin by a bolt extending through the center of the pin and is held to its setting by three stud bolts. The method of carrying the link is also very simple and effective. Complete provision has been made for lubrication by means of oil cups incorporated in different members.

The connection between the valve stem and the cross head is capable of adjustment for setting the valve central after the gear has been erected. This is a provision which is not usually found in the Walschaert valve gear in this country and was adapted from the design applied to the De Glehn compound owned by the Pennsylvania. The arrangement consists of extending the valve stem through an opening in the cross head and securing it by a large nut on either side. These nuts are provided with a flange having 30 teeth cut in its circumference. A locking device is provided which securely fastens both nuts. This arrangement has not proven to be entirely satisfactory and the latest gears have the stem keyed to the cross head and an adjustment provided at the valve itself.

One of the illustrations shows the type of piston valve used on these locomotives, with an enlarged section through the packing ring. These valves were furnished by the American Balanced Valve Co.

A LABOR LEADER'S INDORSEMENT OF A RATIONAL RAILROAD APPRENTICESHIP SYSTEM.—Summing up the whole question of industrial education, as it is supposed to apply to the young men, I am firmly convinced that every precaution should be taken concerning such schools (trade schools), to the end that young men will not be induced or led to believe that after serving a few months, or a year if you will, in an industrial or trades school, by securing certificates they are permitted or even warranted in going into the industrial field seeking employment as mechanics, against the best interests of those who have served a reasonable or legal apprenticeship. To avoid this danger, and with a view to securing the highest skill and to perpetuate the supremacy of the American mechanic, I believe that the proper and best methods to be adopted are for employers to establish schools in connection with their factories and workshops, for the purpose of giving young men employed by them an opportunity for a few hours' schooling each day, in addition to the practical experience they are securing while serving their time as apprentices. To my mind this idea is best carried out by the New York Central Lines, as represented by Mr. Deems.—*From an Address by James O'Connell, President of the International Association of Machinists, before the Civic Federation of New England.*

IMPROVING THE EFFICIENCY OF THE CAR WHEEL.—Finally, to summarize the points that I have endeavored to make and laying aside, for the present, the matter of improving the quality of the wheel, which is a work that must necessarily go on, I would suggest first, avoid the concentration of load by the use of a more satisfactory relation between the contour of the wheel and that of the rail; second, avoid the concentration of heat at or near the flange of the wheel by a modification of the brake practice; third, relieve the oftentimes existing high pressures against the flange by introducing the feature of lateral motion in truck construction, so that a considerable yielding resistance will be offered instead of an abrupt one; fourth, for the purpose of avoiding the excessive wear of wheel flanges of all kinds, modify the contour and provide means whereby the resistance to the pivoting of the truck and of the wheels to track may be very materially reduced.—*S. P. Bush before the Western Railway Club.*

THE FASTEST LONG DISTANCE RUN.—The Pennsylvania has achieved the distinction of carrying a theatrical company from Pittsburg to Chicago in 7 hours and 42 minutes. The special train used was made up of two 60-foot baggage cars and two sleepers. The distance covered was 468 miles, so that the average speed was a fraction under 61 miles an hour, including stops. It is claimed that never before has such a high average speed been maintained for so great a distance by a passenger train. The special was stopped four times and slowed down once by the block signals to prevent overrunning the Pennsylvania's 18-hour train. One of the forced stops was five minutes and the others were nearly as long.

INTERIOR OF STRANG GAS-ELECTRIC CAR "IRENE."

GAS-ELECTRIC RAILWAY MOTOR CAR.

Early in 1906 the Strang Gas-Electric Car Company, New York built the first motor car using its system of power generation and transmission, which was put into service on the Missouri & Kansas Interurban Railway. This car was illustrated and described on page 103 of the March, 1906, issue of this journal. It was followed by several other cars employing the same system, each one being an enlargement and improvement over its predecessor. This series of cars has now received the addition of a very powerful motor car of all-steel construction, which has recently been turned out by the J. G. Brill Company, Philadelphia. This car is named the "Irene," and is shown in the accompanying illustrations.

The Strang system for motor cars consists of a four-cycle six-cylinder gas engine direct connected to a direct current generator supplying current to electric motors on the trucks. In addition there is carried underneath the car floor a large storage battery, which is charged during stops, in coasting down grades, or at other times when the supply of the current from the generator is greater than is required by the motors. This arrangement of storage batteries permits the installation of an electric generator, which is of a size sufficient to meet the normal requirements of operation only. Any excessive call for current can be supplied by calling on the battery to assist the generator. The current from the battery is also used for starting the gas engine by converting the generator into a motor until the engine picks up its charge and is in operation. The electrical connections in this system are such that the battery automatically comes to the assistance of the generator when needed or is automatically charged by absorbing the surplus when the generator supplies more current than is needed by the motors.

The car illustrated is 66 ft. over all and has a capacity of 75 seated passengers. The 150 h.p. gas engine is of the vertical type direct connected to an 85 k.w. shunt wound interpole generator. The motors, of which there are two, are of 100 h.p. capacity each and are of the series wound interpole type. The storage battery contains 112 cells and has a 150 ampere hour capacity.

The car body is of steel construction throughout, with the exception of the interior finish, which is of vermillion wood. The power plant is located at the head end of the car and separated from the other compartments by a partition. Directly behind it is a compartment arranged with transverse seats upholstered in red leather. This section is separated from the rear compartment, which is fitted with wicker chairs and other conveniences of a club car, by a grill partition. An observation platform, surrounded by brass rails, is provided at the rear end

STRANG GAS-ELECTRIC CAR "IRENE."

of the car. The interior finish and arrangement is very elaborate, the lighting, of course, being by electricity. It is heated by the hot water from the engine jackets which is circulated by means of a motor driven centrifugal pump. During the summer seasons the jacket water is passed through a radiator on the roof of the car.

The car weighs, in working order, 57 tons and is capable of hauling three light trailer cars seating 75 passengers each. It is equipped with multiple unit control and can thus be used as a source of power for a number of motor cars connected to it.

This car was on exhibition at the mechanical conventions at Atlantic City, where it was the center of much interest and brought forth many favorable comments.

FREIGHT CAR INTERCHANGE.

The present rules governing freight car interchange were formulated and have been in effect under a period of almost continuous increase in traffic, which has taxed to the utmost the ability of the railroads to provide facilities for its proper handling. These rules are founded on the principle that every car owner has a right to the control of his cars, and each successive change in rules or rates simply emphasized this right.

This principle, although based on strict equity, has had opposed to it the inevitable tendency toward a free interchange or common use of those classes of cars which are adapted to the handling of the general traffic exchanged between railroads.

The extent to which this natural tendency has prevailed over artificial regulations at variance with it, is denoted by the figures showing the per cent. of foreign cars in use on all lines, which increased from 30 per cent. in 1904, to 41 per cent. for the first six months of 1907.

There is food for thought in the fact that the rate of rental for car hire which has not availed in times of car shortage to secure the car owner in the use of his property, operated so effectively immediately on the appearance of a car surplus as to create a new difficulty, the excessive and useless cross haul of empty cars.

It will be noted that the per cent. of cars on their home roads, which was but 56 per cent. during the first half of 1907, and only 54 per cent. during the month of April, 1907, averaged 64 per cent. in December, with indications that the homeward movement had only fairly started. Had this change been accomplished in the natural course of traffic, it might be accepted as a silver lining to the cloud of general depression, but unfortunately it was brought about only at great expense.

The proportion of empty to total freight car mileage in December was 35.4 per cent. as against 27.1 per cent. in October, an increase of 8.3 per cent. It is fair to assume that the average business can be handled with at least as low a percentage of empty mileage when the car supply is plentiful as during a period of shortage, and it would therefore appear that 8.3 per cent. of the total car mileage, or 117,287,407 miles, was absolutely unnecessary. It is impossible to calculate the cost of this enormous empty movement, but that it was a heavy drain on the already depleted revenues of the railroads, cannot be denied. It may be claimed that the saving made by individual roads in per diem balances justified the expenditure which this excess empty movement entailed, but the fallacy of this claim is apparent in the face of the fact that the gain by one line was necessarily offset by the loss to another. Further, in a majority of cases, the movement resulted in practically an even exchange of cars.

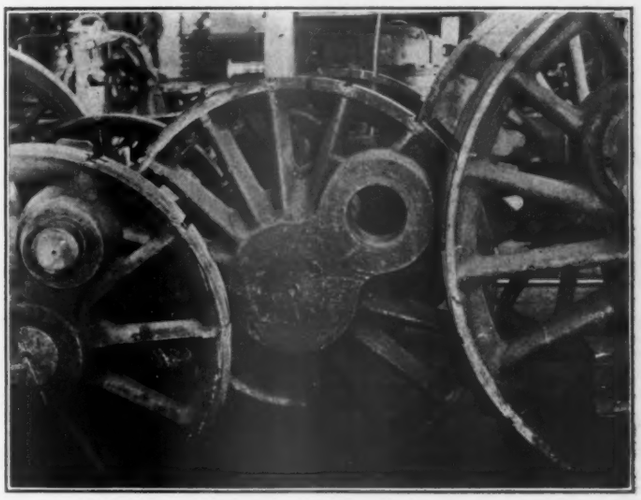
Nor was this wasteful empty movement the only deplorable result of the unfortunate position in which the railroads found themselves. In the efforts to keep per diem balances on the proper side, a great many roads took extreme measures to reduce the number of foreign cars on their lines and to force their own cars into service. Roads which had during the period of shortage, gladly accepted cars belonging to affiliated lines, revised their rules when cars became plentiful and refused to accept cars not properly routing over their lines. Foreign cars were in many instances stopped at junction points and their lading transferred to home cars. In other cases home cars were applied on loading to foreign lines, while foreign cars were sent home empty in the same direction.

There is one encouraging sign in the situation created by the extraordinary developments of the past few months. It is that the experience gained at such great cost may lead to the adoption of more flexible rules governing the use of freight cars in interline traffic. To the extent that such rules recognize the necessity for free interchange of cars, with such regulation as the principle of private ownership demands, to that extent will the future efficiency of freight cars be increased.—*Arthur Hale, Chairman, Committee on Car Efficiency, The American Railway Association.*

TURNING DRIVING WHEEL TIRES.

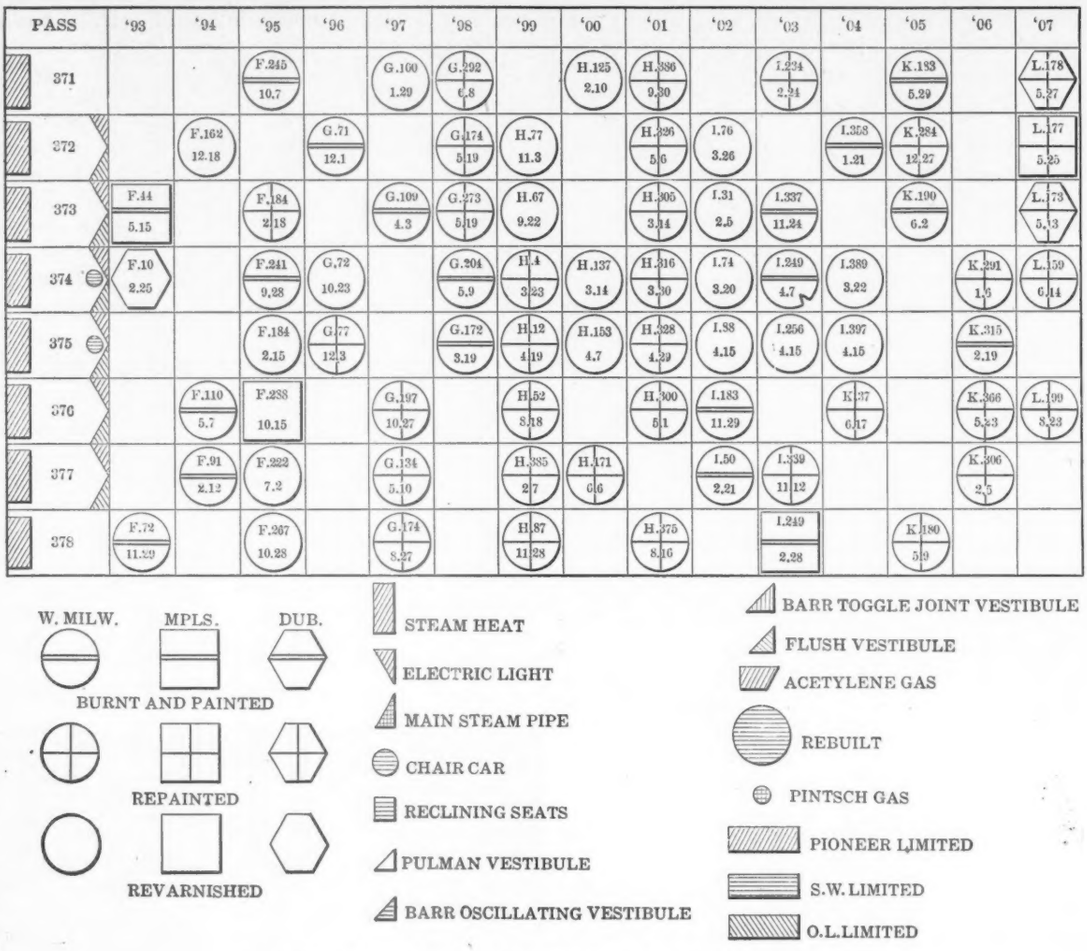
It is often necessary to change and re-turn the tires of an engine two or three times between shoppings. When the tires are sent to the shop for re-turning, the usual practice is to shrink them on an old pair of wheel centers, mounted on an axle, and turn them in the driving wheel lathe. The cost of the labor and gasoline for shrinking the tires on and removing them is considerable. One shop has found that it could handle the tires at about one-half of the cost of turning them in this way by turning them, one at a time, on a boring mill. The mill was an old one and not equipped with a universal chuck.

At the St. Paul shops of the Great Northern Railway a still different method is followed. Old driving wheel centers for 48, 56 and 66 in. wheels are mounted on scrap axles and turned so that the tires will slip over them neatly. Taper key-ways are slotted in the circumference about 18 in. apart. When the tire is slipped on the center, taper keys (1/16 in. to 1 ft.) are driven in, thus holding the tires securely in the centers. The slot and the keys are tapered so that the face of the key and the inside of the tire are parallel when the key is driven tight. They are then turned in the wheel lathe. Only a few minutes are required to set the tires on the centers and the arrangement is said to be very satisfactory. Three sets of these mandrels are all that are required to take care of the greater proportion of the driving wheels in use on the Great Northern; the mandrels when not in use are stored alongside the lathe. A partial view of these mandrels is shown in the accompanying illustration.



MANDRELS FOR TURNING TIRES.

RELATIVE USE OF STEAM, WATER POWER, ETC.—Of the total estimated power at present produced by prime movers in this country, about 26,000,000 horse-power is produced by steam engines, 3,000,000 horse-power by water motors and 700,000 horse-power by gas and oil engines.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*



A PORTION OF COACH PAINT SHOP RECORD BOARD—C. M. & ST. P. RY.

COACH PAINT SHOP RECORDS.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

In the coach paint shop office of the Chicago, Milwaukee & St. Paul Railway, at West Milwaukee, is a series of three or four large boards, about 5 x 8 ft. in size, upon which is shown, in a simple manner, the paint and varnish record of each coach for the past fifteen years. These charts also give information as to some of the important features of the equipment of each car. It is possible to determine quickly the approximate present condition of any coach, and, if it is desired, to refer to the book records for a detail description of what was done to the car at each shopping.

The accompanying illustration, showing a small section of one of these boards or charts, will give an idea as to its arrangement. The number of the car is shown in the column to the left. The vertical divisions are for the different years, each one of the spaces being about 7/8 of an inch square. The tags which are tacked on the board are colored, but as it is impossible to reproduce these colors on the illustration the different tags are distinguished by markings shown in the key at the bottom of the diagram. The actual tags are made of mounted drawing paper painted with a flat oil paint to prevent an early fading of the color.

The painting is done at three shops, West Milwaukee, Minneapolis and Dubuque. To distinguish between the shops at which the work is done the round tags represent West Milwaukee, the square, Minneapolis, and the hexagonal, Dubuque. The heavy repairs in painting are divided into three grades: "burnt and painted," which means painting from the bare wood up; "repainting," which means painting on old paint; "revarnished," which means that the paint has been touched up and varnish applied. The key underneath the diagram shows how these three classes of repairs are distinguished apart. As an example, car 376 was burnt and painted at the West Milwaukee shops in 1894; in 1895 it was revarnished at Minneapolis; in 1897, 1899 and 1901 it was repainted at West Milwaukee, and in 1902 it was burnt and painted at West Milwaukee; in 1904, 1906 and 1907 it was repainted at West Milwaukee. Special tags are used for new cars, upon which the name of the builder and the date the car was placed in service are noted.

The notation at the top of each tag shows the book and page upon which a detail record of the work done on the coach may be found; the lower figures indicate the month and date when the car left the shop and was placed in service. To illustrate, the following records are reproduced for car 374, except that a letter of the alphabet is substituted for the name of the varnish used.

F-241.

Arrived August 1, 1895.
Left September 28, 1895.
Body outside; old paint burnt off; two coats priming; two coats body color; one coat varnish body color; ornamented; two coats "A" body varnish.
Inside varnished.

H-4.

Arrived February 28, 1899.
Left shops March 23, 1899.
Body outside; one coat body color; one coat varnish body color; ornamented; one coat "B" medium body varnish; one coat "B" wearing body varnish.
Inside revarnished in part.

I-74.

Arrived February 26, 1902.
Left shops March 20, 1902.
Body outside; five lineal feet new sheathing; 16 battens; 16 ft. window stool, two panels applied; new parts painted; balance paint touched up, whole body two coats of "C" body varnish.
Inside revarnished in part and part finished in shellac.

I-249.

Arrived March 2, 1903.
Left shop April 7, 1903.
Body outside, paint burnt off in part; new sheathing applied throughout; two coats priming; two coats body color; one coat varnish color; ornamented; two coats "C" body varnish.
Inside revarnished in part and part finished in shellac.

I-389.
Arrived February 23, 1904.
Left March 22, 1904.
Body outside; body color cut in; sign board recolored; ornamented in part; whole body two coats of "A" body varnish.
Inside revarnished in part and polished.

In addition to these records a ledger is kept in which the exact cost of the work for each shopping is shown for each car. The page in this ledger for car 374 is as follows: For obvious reasons the figures showing the costs are fictitious and the trade name of the varnish is represented by a symbol.

PASSENGER CAR 374 FROM DAYTON, O., 11-1-88.

Burnt and Painted	A, 9-28-95	F-241	$192.12	2 "A" Body Varnish
Revarnished	A, 10-23-96	G- 72	127.70	2 "C" "
Burnt and Painted	A, 5- 9-98	G-204	759.50	1 Med. and 1 W. B. "B" Varnish
Repainted	A, 3-23-99	H- 4	295.41	do
Revarnished	A, 3-14-00	H-137	236.26	do
Repainted	A, 3-30-01	H-316	301.14	do
Revarnished	A, 3-20-02	I - 74	206.33	2 "C" Body Varnish
Burnt and Painted	A, 4- 7-03	I-249	247.92	do
Revarnished	A, 3-22-04	I-389	205.18	2 "A" Body Varnish
Repainted	A, 1- 6-06	K-291	211.21	1 Med. and 1 W. B. "B" Varnish
Repainted	A, 6-14-07	L-159	177.85	2 "A" Body Varnish

Tags notched at the lower right hand corner indicate that the car has received new sheathing. The tags in the space occupied by the car number give information as to the equipment of the car, the key to this information being shown below the diagram or chart. For instance, car 374 is equipped with steam heat, as shown by the rectangular tag at the left; is a chair car, as indicated by the small circle at the right of the number; is equipped with electric lights, as shown by the triangular tag in the upper right hand corner, and has a flush vestibule, as shown by the tag at the lower right hand corner. The cars on the "Pioneer" Limited," "Southwest Limited" and "Overland Limited" trains are indicated by large rectangular tags.

These boards occupy very little space, as they are placed one behind the other and are hung from above with counter weights, so that the front ones can easily be raised in order to examine the others. After they are once arranged very little time is required to keep them up to date and it is possible to determine almost at a glance the approximate condition of any car, and with a very few minutes study to determine the general condition of an entire class of cars. A similar board, but more complicated, is maintained in the upholstering department.

We are indebted for information to J. J. Hennessey, master car builder, and Albert T. Schroeder, master painter, under whose direction these charts have been established and maintained.

HORSE-POWER TO DRIVE MACHINE TOOLS.—A good rule for the horse-power required to drive machine tools is to estimate one horse-power for every 10,000 square inches of belt delivered to the machine per minute. This rule is based on a working belt pull of 39.6 lb. per inch of width tending to rotate the pulley, a rule which is justified by the author's experience, and which may be demonstrated as follows: 10,000 square inches of belt per minute = 10,000 linear inches of belt 1 in. wide per minute = 10,000 ÷ 12 linear feet of belt 1 in. wide per minute.

As each inch of width is assumed to carry 39.6 lb. of effective tension, the power transmitted will be:

$$\frac{\frac{10{,}000}{12} \times 39.6 \text{ foot-pounds.}}{= \frac{396{,}000}{12} = 33{,}000 \text{ foot-pounds.}}$$
$$= 1 \text{ horse-power.}$$
$$\text{or H. P.} = \frac{\pi\, d\, w\, n}{10{,}000},$$

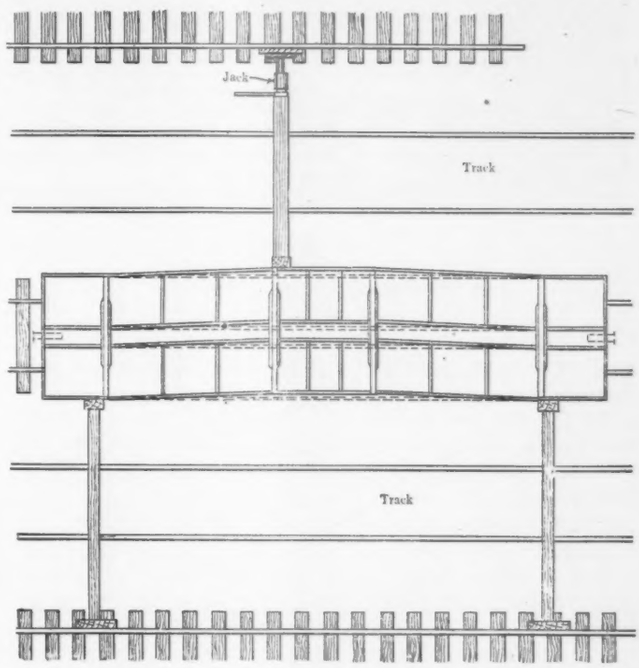
where d = diameter of pulley in inches, w = width of belt in inches, n = turns of pulley per minute.

A tight double belt may transmit twice the amount of power given by the above rule; but although the machine must be strong enough to resist the extra pull, yet it is not wise to provide for double the motive power where separate motors are used, as most motors will stand as much temporary overload as a belt, and no belt will work well long with a permanent overload. —*P. V. Vernon in The (London) Engineer.*

METHOD OF STRAIGHTENING STEEL FRAMES OF WOODEN FREIGHT CARS.

The Rock Island Lines have received, during the past year or two, a large number of freight cars of various types having steel frames. In most cases both the upper and underframes are of steel. It has been found that when these cars are cornered, turned over, or severely treated they will sometimes remain bent and out of line, instead of springing back or breaking in two, as would be the case with wooden cars.

In many cases these distorted frames may be straightened, without cutting the car apart and without stripping, by jacking it back to its original lines. Where a jacking frame, specially made for this purpose, is not available it has been found that the

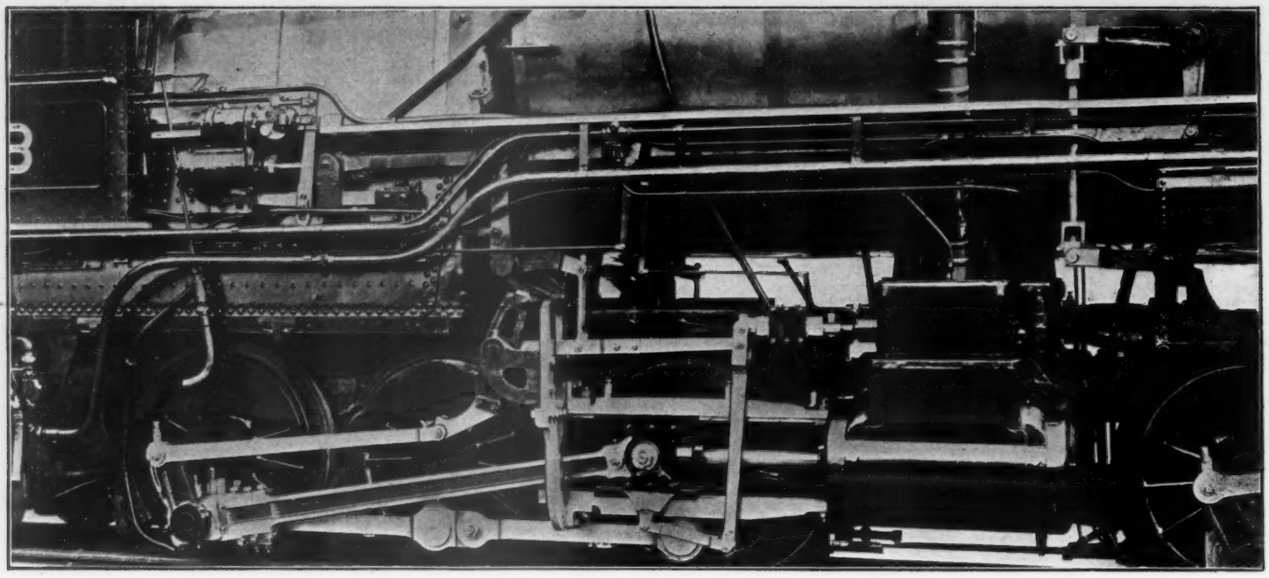


jacking may be accomplished by placing the car so that a footing can be had for the jacks against adjacent tracks, as shown in the accompanying illustration. In some instances distorted underframes have been straightened out by this method at an expense of not over $2.00.

It is not considered necessary or advisable to heat the members of these steel frames for straightening unless the bends are at least 90 degs. The fact that the frames are distorted is not due to weakness or poor design, but registers the fact of their having received unfair treatment, remaining bent instead of springing back or breaking, as is the case with wooden cars. We are indebted for this information to C. A. Seley, mechanical engineer of the Rock Island Lines.

ACCIDENTS ON RAILWAYS.—It is true in the last year, where full returns are available, that 418 passengers were killed on American railroads; it is, however, equally true that we carried 815,778,700 passengers who were not killed. There were 11,185 passengers injured in the same period, 6,778 in train accidents; but again 815,762,933 passengers were carried a little over 25,000,000,000 miles without injury. With these figures I will leave you to the privilege of finding out how many times and how far you can ride on our trains without endangering your life or limb.—*C. E. Lee, Genl. Supt., B. & M., before the New England Railroad Club.*

WOOD FOR PAPER.—The amount of wood consumed in this country for pulp for paper has increased from 2 million to 3½ million cords per year, since 1899. Spruce is the best wood and furnishes about 70 per cent. of the pulp used. The total value of the wood consumed for this purpose in 1906 was $26,400,000.

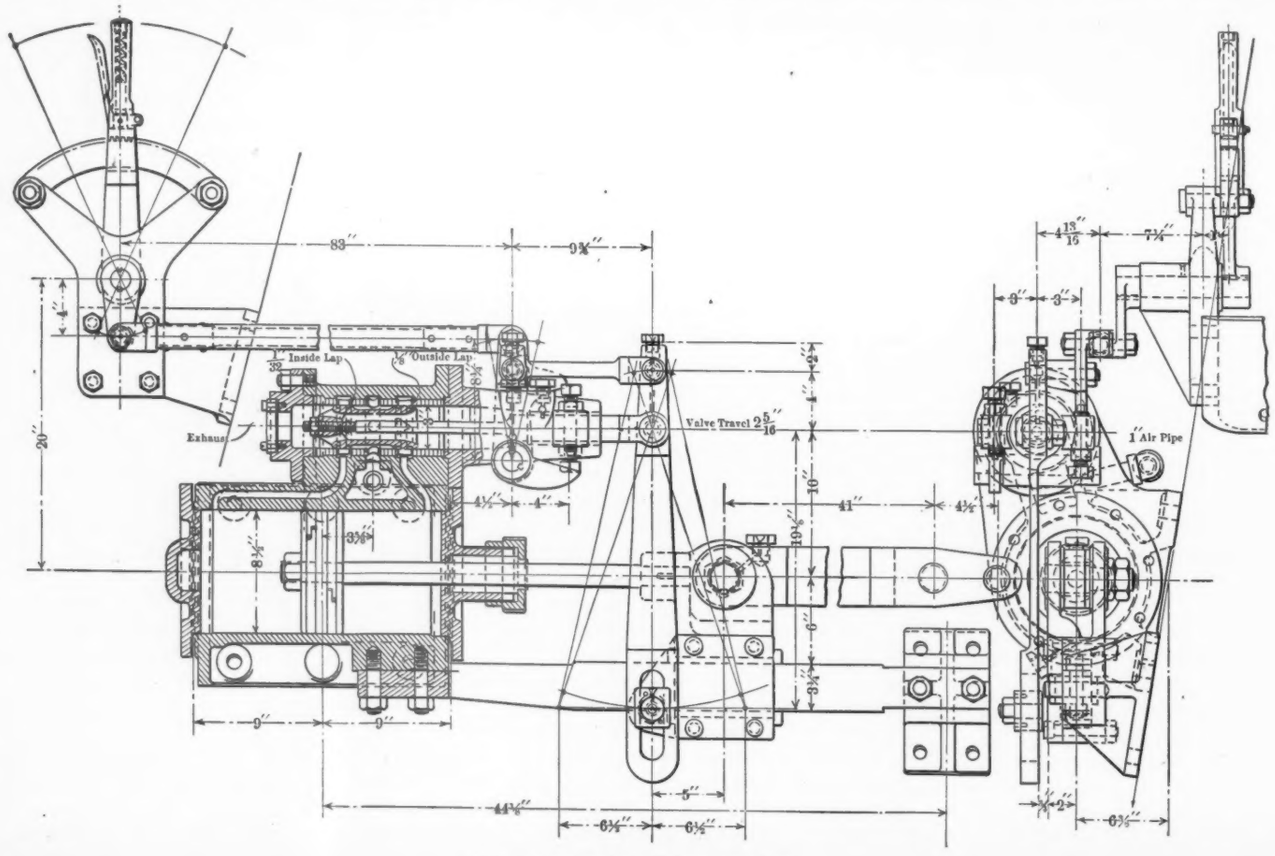


POWER REVERSING GEAR ON MALLET COMPOUND LOCOMOTIVE—GT. NORTHERN RAILWAY.

A POWER REVERSING GEAR.

The Mallet type locomotive requiring, as it does, two complete sets of valve gear makes some sort of a power reversing gear practically compulsory. Several different designs of mechanism for this purpose have been illustrated in the columns of this journal, among which was one, known as the M'Carroll (October, 1906, page 375), applied to the very large locomotives built in 1906, by the Baldwin Locomotive Works, for the Great Northern Railway. Recently a much simpler machine for performing the same work has been designed by the builders and applied to one of these locomotives. It, in general, follows a design which has been very extensively used on marine engines for the same purpose. While railroad and marine service differ in many ways, there would seem to be no important reason why this type of reversing gear could not be made to perform as satisfactory service in the former as in the latter case.

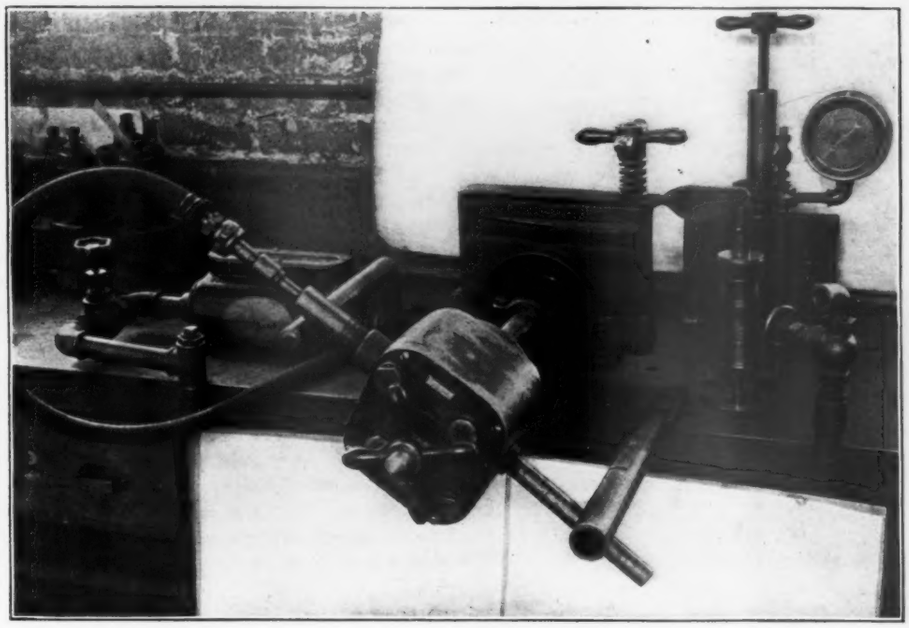
The illustrations show the arrangement and construction clearly and it will be seen that it consists of an 8½ in. air cylinder, the piston in which is connected to a cross head, sliding on a single bar guide. The cross head is connected to the lift shaft by a suitably arranged link. The movement of the piston in the cylinder is controlled by a 3 in. inside admission, piston valve, arranged to give a 1/32 in. inside and ⅛ in. outside lap. The piston valve stem is connected to a combination lever extending vertically from the cross head to which it has a slotted connection. It is also connected by means of a suitable link to the operating lever in the cab. This latter connection is above that



DETAILS OF POWER REVERSING GEAR.

of the valve stem. A rocker is interposed in the connection of the operating lever to the combination lever, which is provided with safety arms, striking adjustable studs, for preventing a movement of the valve beyond the limit of its travel.

The operating lever in the cab is locked in place by a latch and a notched quadrant, and when it is in its central position, with the piston also in the central position, the piston valve will cover both cylinder ports. When, however, the operating lever is moved forward the combination lever swings around its connection to the crosshead as a fulcrum and the valve is moved backward, thus admitting air back of the piston. This then moves ahead and the crosshead carrying the combination lever, which now moves about its upper connection as a fulcrum, carries the valve ahead until it has again reached the central position and cuts off the supply of air. Thus as the operating lever in the cab is moved forward, the piston, and hence the valve gear, follows its movement closely and whenever it is stopped the reversing gear also stops. The gear is so adjusted that when the link blocks have been shifted to the desired cut-off a slight further movement of the piston in this direction will move the valve sufficiently to admit air pressure to the opposite side of the piston and thus lock it securely in place.



PNEUMATIC DRILL TESTER, OMAHA SHOPS, UNION PACIFIC RAILROAD.

PNEUMATIC DRILL TESTER.

In the September, 1907, issue of this journal, page 364, a pneumatic drill tester was described in which the drill was arranged to drive a fine thread screw, with a piston at its lower end, into a cylinder partially filled with oil. The comparative value of the drill was judged by the pressure on the oil when it was stalled.

A more elaborate and satisfactory device, in use in the shops of the Union Pacific Railroad at Omaha, is shown in the photo. The drill socket engages with the prony brake shaft and the body of the drill is kept from revolving by the two arms projecting from the work bench. The amount of air used by the drill is measured by the "Excelsior Aerometer" at the left, which was supplied by G. D. Warren & Co., of Denver, Colo. An air gauge, not shown in the illustration, shows the air pressure. The speed of the drill may be determined by applying a speed indicator to the rear end of the prony brake shaft. Pressure is transmitted from the prony brake shaft to the small oil cylinder, and is shown by the gauge at the right. The supply of oil in the small cylinder may be replenished from the larger cylinder, at the rear, by operating the large screw.

The efficiency of the pneumatic drill is determined by the prony brake pressure and the amount of air used for a given time when the drill is operating at its normal speed. The ultimate capacity of the drill, or its efficiency at any speed, may also be determined, if desired. All of the pneumatic drills in the shop are expected to be turned in once a week, when they are examined and tested, and if found deficient in any respect are repaired. By systematically caring for the drills it has been found that they give far better results in the shop, and that the maintenance cost is greatly reduced. This testing machine was devised by W. H. Anderson, foreman of the air brake and brass department, and by Gus Lawson, one of the machinists in that department.

NEW YORK TO CHICAGO BY TROLLEY.—Some interesting facts are given in the Chicago *Tribune* by the representative of that paper, who recently made the trip from New York to Chicago by trolley. In all he traveled a distance of 1,278 miles, 936 of which were covered on the trolley and 339 on the steam roads. The time spent on the trolley was 42 hours and that on the steam cars 10½ hours. The cost in fares was $23.55, of which $15.22 was paid to the electric railways and $8.35 to the steam roads. The average rate on the electric lines was 1.6 cents per mile; that on the steam lines 2.4 cents per mile. The longest unbroken run by trolley was from Lafayette, Ind., to Westfield, N. Y., a distance of 595 miles. Strangely enough, the longest steam runs were made getting out of Chicago and into New York. The former was 74 miles and the latter about 89 miles. There are only two breaks in the line between Chicago and Buffalo, but there are four between Buffalo and New York.—*Street Railway Journal.*

GROWTH OF ELECTRICALLY APPLIED POWER.—Of the total 30,000,000 horse-power, including the railroads, used in this country, it is estimated that 9,000,000 horse-power, or 30 per cent., is now utilized electrically. This remarkable growth was accomplished in twenty-five years. The use of electric power at the present time is being doubled approximately every five years, as contrasted with the phenomenal doubling of the total power every ten years. If the present rate of increase is maintained, electrically applied power will equal or exceed the power mechanically applied in 1920. The significance of this remarkable increase in the use of electric power in manufactures and other industries lies in the market thus provided for the utilization of our water powers wherever located and whatever their magnitude.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*